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OBSERVATIONS ON THE HUMAN BEING FOLLOWING COLECTOMY OR COLONIC EXCLUSION WITH ILEOSTOMY

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THE colon has certain definite functions. Absorption of fluid and some soluble substances takes place in the cecum, ascending colon, and proximal portion of the transverse colon, or those parts of the colon which are developed with the small bowel from the midgut. Storage takes place in the distal portion of the transverse colon, in the descending colon, and in the sigmoid flexure, which are developed from the hindgut. The colon also serves as a secretory and an excretory organ. These facts have previously been substantiated (6, 9, 12, 15, 20, 24). It can be said, therefore, that the colon plays an important rôle in bodily metabolism and is not the useless catch basin that it was conceived to be by Metchnikoff and Lane (12).

It is known, however, that man can live following the removal or exclusion of the colon. There has been much speculation about the effect of colectomy or colonic exclusion by ileostomy on bodily metabolism, and there also has been much discussion about the ability of the remainder of the intestinal tract to accommodate itself to the loss of the large intestine.

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The purpose of this investigation was to study both the immediate and late effects of total colectomy or colonic exclusion on the human being. Certain phases of the problem have been previously studied with animals, and an attempt has been made to correlate these animal investigations with observations made on human beings. The material studied consisted of 40 cases in which total colectomy was performed at the clinic and 5 cases in which the colon was excluded by ileostomy. Eight of the more recent cases were observed after operation for as long as 8 months, and were observed and studied as late as 5½ years following operation. Colectomy or colonic exclusion by ileostomy was done after more conservative treatment had failed, in an effort to offer the patient improved health. The 3 most frequent indications for these operative procedures were refractory chronic ulcerative colitis, chronic ulcerative colitis with polyposis, stricture or perirectal abscess, and hereditary polyposis.

These patients were studied in regard to changes in their mineral metabolism, postoperative dilatation of the terminal portion of the ileum, changes in the feces, the time required for the passage of test meals, effects of diet on the stools, and the motor activity of the terminal portion of the ileum. The general physical and mental reaction to the

colectomy or colonic exclusion was also investigated. Each case is referred to in all instances by the same number.

MINERAL METABOLISM

Many investigators (15, 23, 24, 27) believed that the colon played a major rôle in the excretion of mineral salts. Schneider found that the excretion of calcium in the urine of dogs was markedly increased following colectomy. The small bowel did not excrete calcium. Johnson did not find that the human colon excreted calcium. Cattell drew attention to a marked loss of chlorides following ileostomy.

If the excessive loss of fluids which follows colectomy or colonic exclusion by ileostomy is sufficient to disturb seriously the physiologic equilibrium of any constituent within the body, it would seem reasonable that the concentration of that constituent in the blood would be altered. Quantitative determinations of the chemical constituents of the blood were therefore carried out in 8 cases (Table I).

Among these cases there were 2 instances of tetany. In both of these cases the tetany was relieved by administration of calcium. In 1 case the tetany occurred 6 months after operation but did not recur subsequently. In the other case tetany occurred repeatedly in association with bouts of diarrhea; examination of the ileum revealed chronic ulcerative disease.

No variations from normal were seen in the values for the urea in the blood or in the values for the phosphorous and total protein in the serum. In only 1 case was there a reduction of the value for the chloride in the plasma. However, following operation there was a moderate decrease in the values for calcium in the serum; this was consistent enough to be of significance. The values for calcium in the serum were all restored to normal in all cases at the end of the first month after operation, and remained within normal limits thereafter. This would suggest that colectomy or colonic exclusion with ileostomy does not give rise to serious disturbances of the chemical constituents of the blood which were studied.

DILATATION OF THE TERMINAL PORTION OF THE ILEUM FOLLOWING COLECTOMY OR COLONIC EXCLUSION WITH ILEOSTOMY

In dogs which were subjected to colectomy and ileorectostomy, a dilatation of the terminal portion of the ileum has been noted. Weiss and Porcher, Schneider, and Canavero (5), who made roentgenologic studies of dogs by using barium enemas, found a dilatation of the terminal portion of the ileum which they believed had progressed for several months to the point where the dilated ileum compared volumetrically with the removed colon; in other words, there was a volumetric compensation. No similar studies seem to have been recorded after an ileostomy.

As a preliminary study, in 36 cases in which the colon and terminal portion of the ileum were normal, roentgenograms were made after the administration of a barium enema, in order to determine the average diameter of the terminal portion of the ileum. The technique was constant and similar to that used in the cases in which ileostomy was performed. The mean and average diameter of the terminal portion of the ileum was found to be 2 centimeters.

Anatomic texts give the average diameter of the terminal portion of the ileum as 2 centimeters to 2.5 centimeters, but examination of segments of living bowel removed incident to performing an ileostomy or ileocolostomy revealed that the diameter was 1.6 centimeters. Roentgenologic examination of the terminal portion of the normal ileum revealed that the average diameter was 2 centimeters, as did the pre-operative roentgenograms in Cases 3, 6, and 7.

The terminal portion of the ileum was subjected to examination in 6 cases to determine the presence or absence of dilatation following ileostomy and the extent of the dilatation, if present. In 5 cases the patients were subjected to 1 or more roentgenologic examinations. Those cases in which operation was performed following ileostomy, or in which the patients came to necropsy likewise were studied. The roentgenographic studies were made after the administration of a barium enema. A catheter was introduced into the ileac stoma and barium under minimal pres-

TABLE I.—QUANTITATIVE ANALYSIS OF BLOOD BEFORE AND AFTER ILEOSTOMY WITH OR WITHOUT COLECTOMY

Case	Operative procedure	Urea, mgm. per 100 c.cm. of blood				Chlorides, mgm. per 100 c.cm. of plasma			
		Before operation		After operation		Before operation		After operation	
		Interval	Value	Interval	Value	Interval	Value	Interval	Value
1	Colectomy*	2 days	16	7 days	18	2 days	660	7 days	594
2	Ileostomy	2 days	20	7 days	14	2 days	553	7 days	604
				1 month	30			1 month	585
3	Colectomy			5½ years	28			5½ years	602
				5½ years	28			5½ years	672
4	Ileostomy	3 days	28	10 days	21	3 days	594	10 days	591
				1 month	16			1 month	590
5	Ileostomy	2 days	18	6 months	22			6 months	627
				6 months	36			6 months	594
6	Ileostomy							9 months	600
				9 months	20			9 months	564
7	Ileostomy			5 days	46			5 days	602
				12 days	42			12 days	616
				19 days	22			19 days	594
				21 days	36			21 days	604
				1 month	18			1 month	585
				4 months	24			4 months	594
				7 months	20			7 months	594
	Colectomy			5 days	22			5 days	561
				12 days	16			12 days	594
8	Ileostomy†	3 days	15	7 days	20	3 days	578	7 days	479
				1 month	62			1 month	503
		Calcium, mgm. per 100 c. cm. of serum				Phosphorus, mgm. per 100 c. cm. of serum			
1	Colectomy*	2 days	9.3	7 days	7.8	2 days	3.8	7 days	3.0
2	Ileostomy	2 days	9.3	7 days	8.2	2 days	3.6	7 days	3.2
				1 month	9.6			1 month	3.0
3	Colectomy			5½ years	10.2			5½ years	3.0
				5½ years	9.9			5½ years	2.9
4	Ileostomy	3 days	8.9	10 days	9.2	3 days	2.9	10 days	3.5
				17 days	9.2				
				1 month	10.3			1 month	4.4
5	Ileostomy	2 days	9.2	6 months	9.2			6 months	4.2
				6 months	9.2			6 months	3.6
6	Ileostomy			9 months	9.5			9 months	4.2
				9 months	9.5			9 months	3.9
7	Ileostomy			5 days	9.8			5 days	4.2
				12 days	9.1			12 days	4.4
				19 days	9.7			19 days	4.8
				1 month	10.0			1 month	4.0
				4 months	10.2				
	Colectomy			7 months	9.4			7 months	3.3
8	Ileostomy†	3 days	8.2	7 days	8.2	3 days	4.4	7 days	3.4
				1 month	10.2			1 month	6.6

*Ileostomy performed 3 years before colectomy.
†Severe chronic ulcerative colitis and diarrhea present before operation.

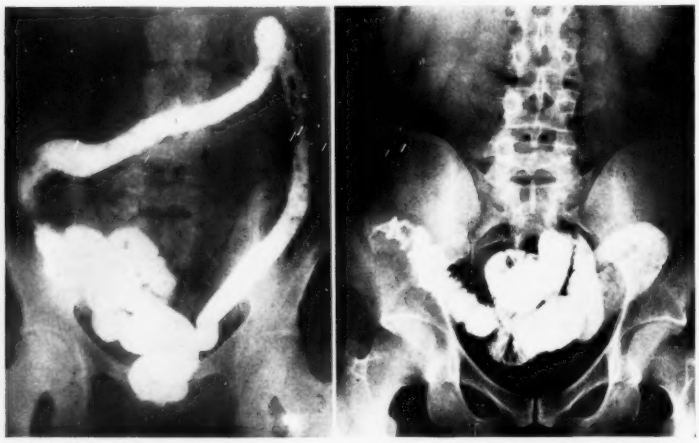

Fig. 1. Terminal portion of ileum in Case 3; a, left, before operation; b, after operation.

sure was allowed to run in slowly and intermittently under fluoroscopic observation, until the loops of the ileum began to superimpose themselves on each other. Roentgenograms were then made after any excess barium had been expelled. The visualized loops were examined and their diameters determined. Table II gives the average diameters of the loops of the terminal portion of ileum in the 5 cases studied. Intestinal activity, as studied by fluoroscopic examination, seemed normal in all of these cases. In 3 of these cases preoperative roentgenologic examination, which was made after the introduction of a barium enema, revealed that the diameter of the terminal portion of the ileum was normal (Figs. 1 and 2).

TABLE II.—DIAMETER OF TERMINAL PORTION OF ILEUM AS DETERMINED BY ROENTGENOLOGIC EXAMINATION FOLLOWING ADMINISTRATION OF A BARIUM ENEMA

Case	Pre-operative diameter, cm.	Postoperative diameter	
		Interval after operation	Diameter, cm.
3	1.9	5½ years	3.2
4		1 month	2.8
5		6 months	3.0
6	2.2	9 months	2.8
7	1.9	1 month	3.2
7		4½ months	3.2
Average	2.0		3.0

Observations were also made at the time of operation, that is, with the abdomen opened. In Case 7, at the time of the ileostomy the terminal portion of the ileum measured 2 centimeters in diameter, and at the time of colectomy it was estimated to be dilated in a 3:2 ratio with the normal ileum. The 12 centimeters of ileum removed with the colon had a diameter of 1.6 centimeters.

In Case 4, at the time of ileostomy the diameter of the terminal portion of the ileum was 1.6 centimeters. Dilatation was definitely present at the time of colectomy. At necropsy, the terminal portion of the ileum measured 2.4 centimeters after it had been in formalin for a few days.

In Case 1, in which colectomy was performed 3 years following ileostomy, the terminal portion of the ileum was definitely dilated to approximately 3 centimeters in diameter.

In the cases in which an ileostomy was performed, roentgenologic examination revealed that the average diameter of the terminal portion of the ileum was 3 centimeters and operation or necropsy revealed a similar dilatation which could not be measured accurately. The dilatation does not seem to

a b c

Fig. 2. Terminal portion of ileum in Case 7; a, before operation; b, 1 month after operation; c, 4½ months after operation.

be progressive after the first month. In the absence of impeding strictures or sphincters it is thought that the dilatation is probably physiologic. There is no evidence, however, that the amount of dilatation present is sufficient to compensate volumetrically for the excluded colonic reservoir.

EXAMINATION OF THE STOOLS

Since colectomy was first performed it has been known that this procedure is followed by an early, progressive thickening of the stools. Canavero (5), Deutsch, Weiss and Porcher, and many others have noted that colectomized animals and patients who have been subjected to an ileostomy have an intractable diarrhea in the immediate postoperative period. The water content of the stools of dogs that have been subjected to ileorectostomy has been demonstrated to be 90 to 95 per cent; this corresponds closely with the percentage of water in the contents of the normal ileum, which, according to Luciani, is 90. The reaction of the discharge from the terminal portion of the ileum has been carefully studied under various conditions. Heile, as well as Hosoi, Alvarez, and Mann, found that the discharge was alkaline or neutral to litmus. Luciani, Dean, Bollman and Mann, and others have studied the reaction of the contents of the terminal portion of the ileum after the ingestion of carbohydrate, fat, or protein. The content was usually alkaline, with occasional excursions to the acid side, particularly after the ingestion of fatty meals.

Likewise, Hosoi, Alvarez, and Mann have studied the time required for carbohydrate, protein, or fat to pass through the small intestine. The average time that was required for these substances to pass through the small intestine of dogs which had been subjected to colectomy was 1½ hours to 4½ hours. It was thought that carbohydrate frequently passed through the small intestine more rapidly than did protein or fat.

The stools were studied in 6 of the cases under observation. The stools in some of these cases were observed from the day of operation for as long as 8 months, and in other cases at intervals up to 5½ years after ileostomy and colectomy. The color of the stools was light to dark brown. The odor of every 24 hour specimen was fecal but the stool at the time of expulsion usually had little odor.

The reaction of 23 specimens which were collected for 24 hours and the reaction of 23

specimens which were collected at the moment of expulsion were studied. Litmus was thought to be sufficiently accurate for the purpose. The reaction of the stool at the moment of expulsion was alkaline in each case. The reaction of the 24 hour specimens was acid.

There was a definite change in consistency of the stools in all cases. The consistency of the stools was graded 1 to 4; grade 1 was used to classify those stools which were practically formed and grade 4 was used to classify those which were practically fluid. The stools in Cases 4, 7, and 8 were observed from the day of operation. The first 24 hour specimen, which in each case was obtained on the third day, was entirely fluid and consisted of 800 cubic centimeters to 1,000 cubic centimeters of fluid containing approximately 50 cubic centimeters of sediment. At the end of 10 days there was an increase in sediment, and at the end of 2 weeks the stools had become uniform in consistency. Only at the end of a month was a definite thickening of the stool noted. They were graded 3, as they contained little fluid but no formed matter. This thickening was progressive for 3 months. There seemed to be little change after that. Stools which were grade 2, that is, stools which contained some formed matter, were noted 6 months after operation in Case 5, 9 months after operation in Case 6, and 4½ months after operation in Case 7. In Case 7 no further change in the consistency of the stools was noted 7 months after the operation. Five and a half years after operation the consistency of the stools in Case 3 was grade 2 on 2 occasions and grade 1 on another occasion. One or more years after patients had been subjected to colectomy they usually reported that the stools were semiformed most of the time but also said that the stools occasionally were very loose. Little change in the stools was noted after the fourth month.

In Case 7 the percentage of water in the stools varied from 90.8 to 92, 4½ months after ileostomy; in Case 5 it varied from 91.2 to 93.2, 6 months after ileostomy; and in Case 3 it varied from 89.2 to 91.5, 5½ years after ileostomy. In the last case the percentage of water was determined in very hot weather, which might have accounted for the slight decrease.

The weight of the 24 hour specimens of feces was repeatedly determined in 5 cases. The average weight of the stools passed in 24 hours by a normal individual who is receiving an unrestricted general diet is 170 grams (17, 25). While the patients in these cases were eating an unrestricted general diet, the weight of the stools which were passed in 24 hours varied from 316 grams to 596 grams, the average weight being 433 grams. There was no progressive reduction in the weight of the stools after operation in any case. Some of the heaviest stools were found in Cases 3 and 5, 5½ years and 6 months, respectively, after ileostomy.

The fact that the discharge from an ileac stoma becomes progressively less liquid for some time after the ileostomy has been performed and the possibility that this phenomenon is related to changes in the time that the ingested material remains in the small intestine prompted us to study the rate of passage of ingested material through the small intestine and to compare this with the consistency of the discharge from the ileac stoma. In order to identify the stools for a given period, 5 grains (0.3 gram) of carmine was administered with the breakfast and the first appearance of the carmine was observed in the ileac discharge (Table III). The average time that is required for ingested material to reach the ileocecal region of normal subjects is from 2 to 4½ hours. The average time required for ingested material to reach the ileac stoma in the cases studied was 3 hours and 24 minutes. There did not seem to be any relation between the consistency of the stools and the time required for ingested material to reach the ileac stoma. In fact, it was discovered that in the cases in which the time required for the passage of ingested material through the small intestine was observed several months and 5½ years after operation, the time was comparable to that observed immediately after the operation. In Case 3, the time required for the passage of material through the small intestine was slightly less than the average for

TABLE III.—CONSISTENCY OF STOOLS AND TIME REQUIRED FOR INGESTED MATERIAL TO PASS THROUGH THE SMALL INTESTINE

Case	Operative procedure	Postoperative interval	Time required for ingested material to pass through small intestine, hours and minutes	Consistency of stools, grade
3	Colectomy and ileostomy	5½ years	2:25	1+
			3:13	2
			3:30	1+
			4:00	2
4	Ileostomy	2 weeks	2:15	3
		4 weeks	2:30	2+
5	Ileostomy	6 months	2:00	2
			2:00	2
			5:30	2+
			4:25	
			2:05	2+
			4:15	2
			4:45	1+
			4:00	2
			4:15	
6	Ileostomy	9 months	4:25	2
7	Ileostomy	2 weeks	4:00	3
		3 weeks	4:00	3
		4 months	2:45	2
			3:00	2
			2:15	2
			2:15	2
8	Ileostomy	1 month	4:15	3
Average			3:24	2

the group of cases, although the stools were grade 2.

Carefully calculated diets were given in 2 cases. All studies were made on the second day of administration of each diet. Alterations in the diet caused little variation in the stools or in the time required for ingested material to pass through the small intestine. The average water content of the ileac dejecta was 91.3 per cent, as compared with the average water content of the normal stool, which is 76 per cent.

This study did not indicate that the carbohydrate, protein, or fat in the diet should be limited in order to influence the activity of the ileac stoma.

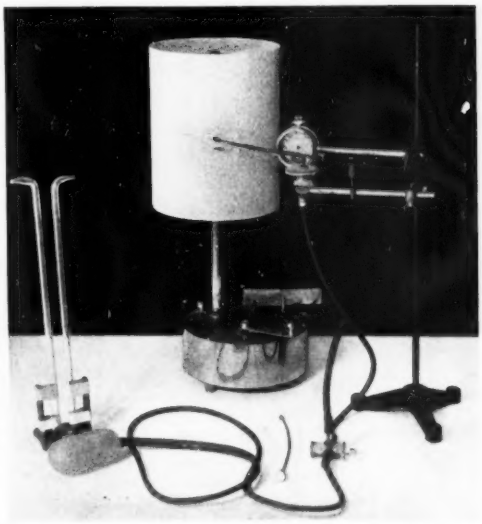

Fig. 3. Apparatus used to record motor activity of intestine.

MOTOR ACTIVITY OF SMALL INTESTINE

It is important to determine the part the motility of the small bowel plays, if any, in the progressive thickening of the stool and in the apparent reduction in the activity of the ileac stoma some time after colectomy has been performed.

Fundamental studies by Bayliss and Starling, Alvarez, Krishnan, Short, Hertz, and Castleton, have revealed certain facts concerning the motor activity of the terminal portion of the ileum. Two types of contractions have been noted, pendular (rhythmic) and peristaltic (tonic). The pendular movements were segmental and constant; they occurred at the rate of 8 to 14 per minute. Peristaltic waves arose at any point, ran any distance, and occurred at less frequent intervals. The bowel was always active, but was relatively quiet during a fasting period. The taking of food by mouth brought about increased activity, which was more marked following a fast than it was following a recent meal.

Weiss, who studied the terminal portion of the ileum of a dog which previously had been subjected to colectomy and ileorectostomy,

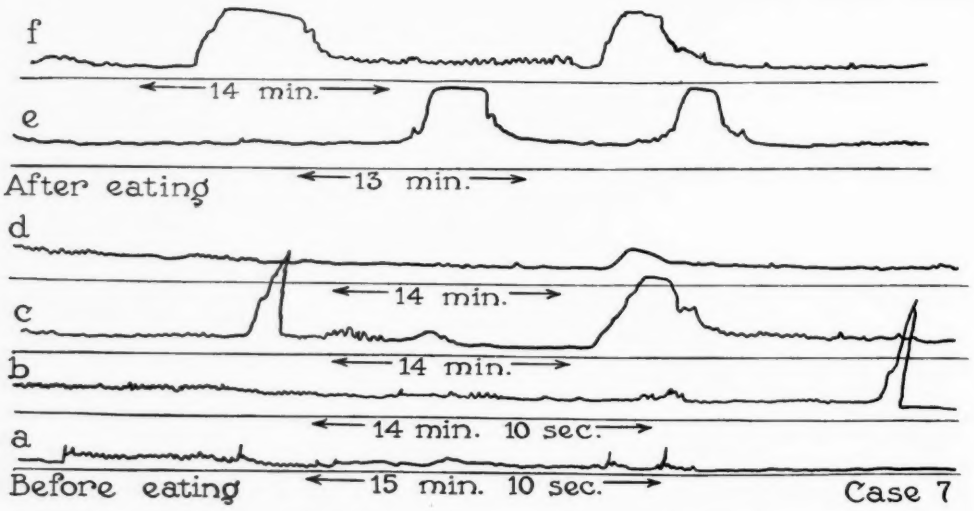

Fig. 4. Intestinal tracings made 3 weeks after operation in Case 7.

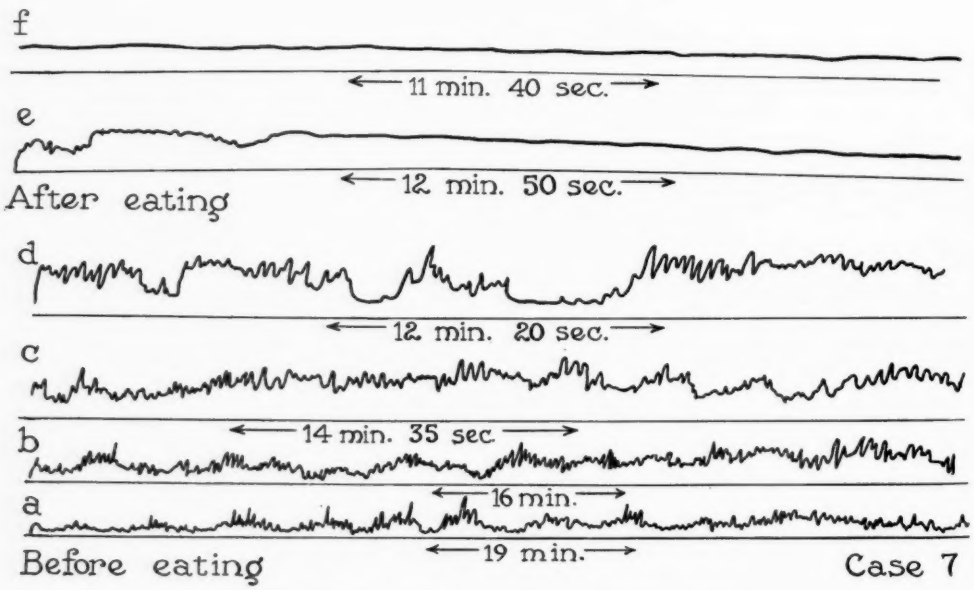

Fig. 5. Intestinal tracings made 4½ months after operation in Case 7.

TABLE IV.—INFLUENCE OF EATING ON INTESTINAL TRACINGS THROUGHOUT THE POSTOPERATIVE PERIOD

Time after operation	Rhythmic contractions				Tonic contractions								General level of contractions, centimeters	
	Before eating		After eating		Before eating		Duration		After eating		Duration			
	Rate per minute	Amplitude, centimeters	Rate per minute	Amplitude, centimeters	Number of contractions in 10 minutes	Amplitude, centimeters	Minutes	Seconds	Number of contractions in 10 minutes	Amplitude, centimeters	Minutes	Seconds	Before eating	After eating
17 days	11.4	Minimal	Obliterated		5	2		25	7.4	2.5		54		
3 weeks	9.4	Minimal	8.9	Minimal	1.3	4.7	1	2	1.5	4.4	1	35	1.2	1.2
6 weeks	11.2	0.8	11.0	0.8	4.3	1.7		54	4.3	2.3	1	9	1.7	2.3
4½ months	10.2	0.8	8.3	Minimal	5.0	1.7	1	2	7.4	1.9	1	15	0.9	1.4
6 months	9.8	0.7	9.4	0.7	2.7	3.9	1	14	4.3	4.4		52	1.0	1.8
8 months	10.3	Minimal	9.3	Minimal					4.3	2.1		53	1.5	1.9
9 months	12.9	Minimal	11.3	Minimal	1.5	1.5			1.5	1.7			1.0	1.0
5½ years	9.0	1.2	7.9	2.0	2.5	4.8	1	6	7.4	4.8	1	18	1.3	3.7

expressed the opinion that the motility of this portion of the ileum became colonic in type, and he believed that this caused progressive thickening of the stool by slowing the passage of the material through the terminal portion of the ileum.

Studies of motor activity of the intestine were carried out in 5 cases in order to determine what influence intestinal motility might have on the progressive thickening of the stool. Points studied concerned a comparison of the type of tracing obtained and the known normal motor activity of the ileum, the effect of the ingestion of food during the tracing, and the progressive change, if any, in the motor activity of the intestine when reexamined at intervals during the postoperative period. Tracings were made as early as 17 days and as late as 5½ years after ileostomy. In 1 case 3 different tracings were made in 8 months, 2 tracings were made in 2 cases, and 1 tracing was made in 2 cases. Two of the tracings were made after fasts of 16 hours; these tracings were made for 3 hours; 2 meals were given in this time. All other tracings were made 3 hours after the patient had eaten; a light lunch was given while the tracing was being made. All tracings were continuous. The apparatus used was simple. A balloon, which measured 10 by 4.5 centimeters when inflated, and which was attached to a recording tambour by sealed rubber tubing, was introduced into the ileum for a distance of 15 centimeters. Air under a pressure of 8 centimeters of water was used to inflate the balloon. Accurate time records were made in all cases. Figure 3 shows the apparatus which was used.

Two types of contractions were recognized in the tracings, namely, rhythmic contractions and tonic contractions. The rhythmic contractions, which were more constant but weaker than the tonic contractions, represented the rhythmic segmenting movements of the intestine. The tonic contractions probably represented peristaltic waves for they were often accompanied by the expulsion of gas and feces. We observed the variations in the height, duration, and frequency of the contractions, as well as the general level of the contractions as measured from the constant base line.

In Case 7, the tracings which were made 3 weeks and 4½ months, respectively, after ileostomy were continued for 1½ hours. The usual diet of milk and crackers was given 1 hour after the tracings were started. Tracings were again made 8 months after ileostomy; these were started after a fast of 16 hours and were continued for 3 hours. A full meal was served 40 minutes after the tracings were started. In this case the motor activity of

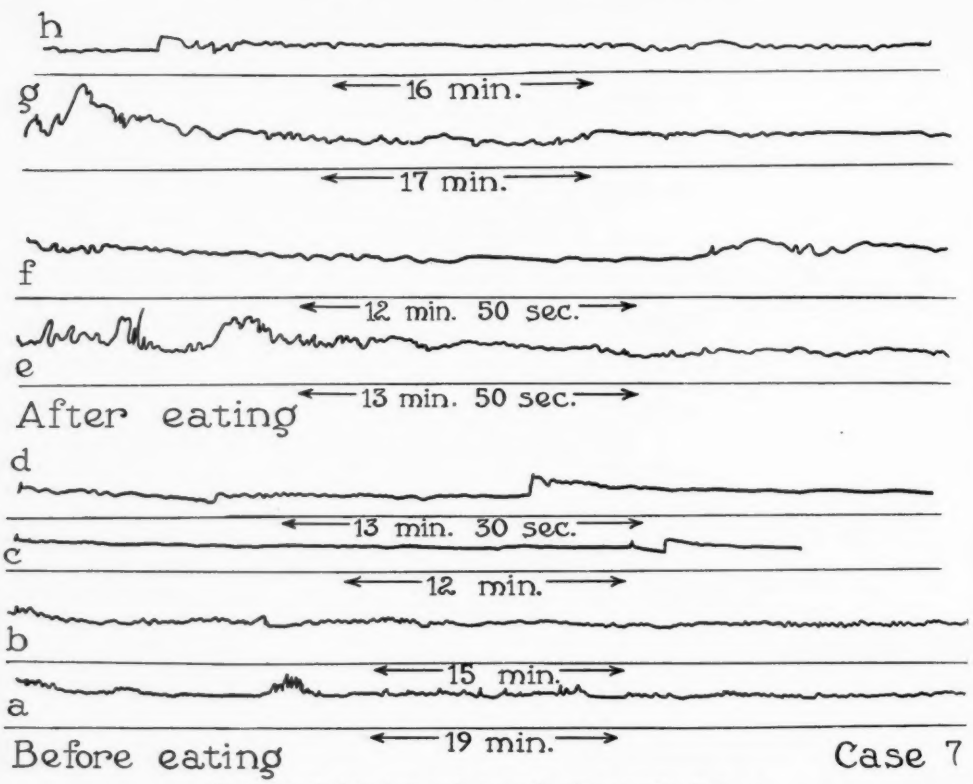

Fig. 6. Intestinal tracings made 8 months after operation in Case 7.

the intestine was observed for 8 months. No fundamental change was noted in the rhythmic contractions during this period. There was a decrease only in the amplitude of the tonic contraction waves. Eating brought about a variable increase in the tonic contraction waves (Figs. 4, 5, and 6). In Case 3, the tracing was started after a fast of 16 hours and was continued for 3 hours. A full meal was served 40 minutes after the tracing was started and another full meal was served an hour and a half later. The intestine was rather active even after the fast. The first meal brought about a marked increase in the activity of the tonic contraction waves and in the general level of contractions, but after the second meal these changes were not so marked. These findings corresponded to the periods of intestinal activity which had been observed by the patient. No fundamental change from the normal motor activity of the ntestine was noted (Fig. 7).

If the group of cases is studied as a whole certain facts regarding the motor activity of the terminal portion of the ileum become apparent following ileostomy. There was no slowing of the rate or decrease in the amplitude of the rhythmic contraction during the period following operation. No progressive reduction in the activity of the tonic waves was noted and there was no evidence of any reduction in the tone of the bowel. It may be said that during the time the stool is becoming thickened and the ileac stoma is said to be "quieting down," there is no evidence to support the theory that this adjustment is brought about by a progressive change in the motor activity of the bowel.

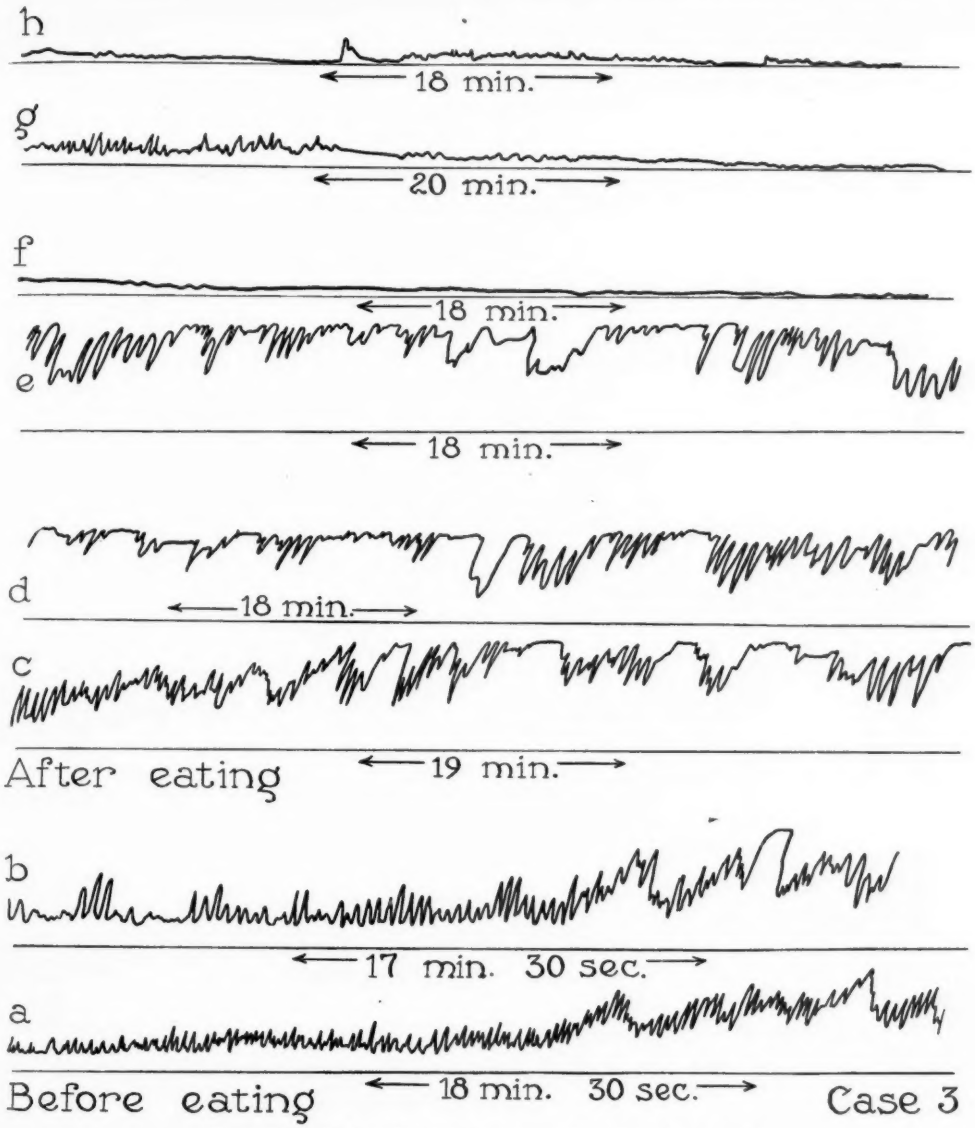

Fig. 7. Intestinal tracings made 5½ years after operation in Case 3.

We did not note any change in the effect of eating on the motor activity of the terminal portion of the ileum throughout the period following operation (Table IV). There was a variable increase in activity of the tonic contraction waves after eating. The apparent change in the rhythmic contractions was ascribed to their partial or complete obliteration by the tonic contractions after the patient had eaten. However, the changes in the

tonic contractions can be explained only by the fact that the ingestion of food stimulates the terminal portion of the ileum to stronger tonic (peristaltic) contractions; this stimulation does not change throughout the period of adjustment following operation. The increase in the strength of the tonic contractions occurred within 3 or 4 minutes after the beginning of ingestion of the meal, except in 1 case in which the response occurred 30 minutes later. The degree of increase varied considerably.

From these studies it may be said that there is no fundamental change in the motor activity of the ileum after ileostomy with or without colectomy. No fundamental change in the stimulating effect of the ingestion of food was noted during the postoperative interval. The intestinal tracings at all times were typically tracings of the small intestine and there was no suggestion that the motility of the terminal portion of the ileum becomes colonic in type, as has been suggested by experiments on dogs (28). The thickening of the discharge and the decrease in the number of discharges from the ileac stoma can in no way be ascribed to changes in the motor activity of the ileum.

PHYSICAL AND MENTAL REACTION TO COLECTOMY OR COLONIC EXCLUSION BY ILEOSTOMY

Close observation of 8 patients throughout prolonged postoperative periods and a careful inquiry into the condition of the patients in 37 other cases afforded an opportunity to compare the general physical and mental changes with the changes already noted.

The patients began to regain their strength approximately 1 month after operation. In the next 2 or 3 months the strength returned to normal. Little change was noted thereafter. There was a substantial gain in weight in each case after operation. In cases which were reviewed later than 1 year following operation, the patients reported that they were in better health than they were before the operation and they seemed to have average strength.

The number of discharges from the ileac stoma began to decrease 2 weeks after the operation and continued to do so for 3 or 4 months. At first, it was necessary to change the dressings 3 or 4 times each night but 3 months after the operation it rarely was necessary to change the dressing or bag at night. During the day, the bag was emptied 3 or 4 times. Activity was marked immediately after meals, and was prolonged after breakfast, when the activity often lasted an hour. Regularity of meals influenced the activity of the ileac stoma. The activity was decreased at night if the heaviest meal was taken at noon. Expulsion of gas created no problem or embarrassment after 3 months. As a rule, there was little trouble with foods beyond the individual variations seen among normal people. Ingestion of citrous fruits and fibrous vegetables in excess or drinking excessive amounts of water made the stool more liquid.

The most advantageous position for the ileac stoma was in the right lower quadrant of the abdomen. This permitted the bag to be worn in line with the thigh. If the ileum protruded about 3 centimeters the type of bag usually worn fitted about the bowel better than it did if the ileum was not allowed to protrude. Kaolin mixed with glycerin or petrolatum or ointment of zinc oxide was used on the surrounding skin, as necessary. However, the skin about the ileac stoma caused little trouble.

All patients studied were asked to express their mental reaction to an ileac stoma. Until the physical condition of the patients improved their mental attitude was less hopeful than it had been, but after 2 or 3 months the attitude was one of acceptance in preference to their previous condition. In the cases studied the patients came from all walks of life. They returned to their previous occupations and enjoyed sports, including swimming, as well as all social activities. They were better able to resume their economic and social activity than they were before operation. One woman said that she was able to play golf and dance. Four years after ileostomy and colectomy one man said: "I have established lifelong habits . . . . The use and care of an ileostomy becomes habitual and one gives it little thought." Another man said: "So long as I can live in convenient sur-

roundings I expect always to be just as happy with an ileostomy as I was without one, and certainly far happier and leading a fuller life than I did while suffering from chronic ulcerative colitis." It is to be remembered, however, that before operation these patients were in poor physical and mental condition, which made the toleration of an ileac stoma easy when their health improved.

SUMMARY

This paper is based on a study of 45 cases; colectomy was performed in 40 cases and the colon was excluded in 5 cases. The values for the serum calcium are slightly reduced following colectomy or ileostomy but return to normal within a month. Colectomy or ileostomy does not otherwise disturb the physiologic equilibrium of the chemical constituents of the blood. Roentgenologic visualization or the appearance of the terminal portion of the ileum at operation or necropsy revealed a definite but not a marked dilatation. There was no evidence that the dilatation was sufficient to compensate volumetrically for the excluded colonic reservoir. Stools from the ileac stomas were alkaline. The average weight of the stools while the patients were eating a general diet was 433 grams and the water content was 91.2 per cent. The watery discharge gradually thickened during the first 3 months; at this time the stools were soft and occasionally contained some formed matter. This thickening of the stool is unrelated to the time necessary for the ingested material to be expelled from the ileac stoma.

Intestinal tracings at all times were characteristic of tracings of the small intestine. Taking of food increased the intestinal activity, especially following a fast. There was no fundamental change in motor activity or in the intestinal response to the ingested food throughout the prolonged period following operation. The thickening of the discharge and the decrease in the number of discharges from the ileac stoma can in no way be ascribed to changes in the motor activity of the ileum. A period of 3 months is necessary for the patients to regain their average weight and strength. No permanent deficiencies in body metabolism follow ileostomy. A general diet can be taken. Special care of the ileac stoma becomes minimal. The mental attitude, which improves with the physical condition, is one of acceptance in preference to the former state. The patients are able to resume their economic and social activities.

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ACUTE PERFORATION OF PEPTIC ULCER

An Evaluation of Contributory and Exciting Causes

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WHEREAS Finch (12) described the first case of peptic ulcer in 1670; the increasing relative importance of the disease did not begin to manifest itself until about 4 decades ago. At the present time probably not any feature of the disease is so little understood as the etiology. As an example of the recent state of our knowledge, McCann devotes no less than 30 pages to a review of theories concerning the etiology of peptic ulcer. The existence of this uncertainty, therefore, requires from time to time a reconsideration of the numerous factors which at least are contributory to the production of peptic ulcer and its complications. It is the purpose of this paper to contemplate the causes of ulcer along with other factors as they appear to conduce to its most serious complication, namely, acute perforation.

This study was made from the clinical records of 500 cases in which acute perforation complicated benign peptic ulcer. The features which are believed to be of etiological significance have been evaluated in terms of the percentage of cases in which each feature was present. A group of 500 cases derived from the same source and subjected to the same degree of critical analysis is believed to be sufficiently large to warrant certain conclusions.

LITERATURE

An attempt will not be made here to review the voluminous literature on the etiology of acute perforation of peptic ulcer. A brief review of certain articles, however, will serve to indicate the trend of modern thought on this phase of the problem.

The incidence of acute perforation in peptic ulcer has been investigated by several authors. Eliason and Ebeling reported that in a series of 729 cases of peptic ulcer from the combined records of services at the University of Pennsylvania and Philadelphia General Hospitals there was an incidence of perforation in slightly over 10 per cent. In 880 cases diagnosed as peptic ulcer, Brown reported slightly over 11 per cent of proved perforations. In a report on the incidence of perforation of peptic ulcer among soldiers in the United States Army, Troutt reported that whereas this complication occurred on the mainland in 7.77 per cent of cases, it was over four times as frequent among soldiers stationed in Hawaii.

An observation on the racial incidence of acute perforation was made by Brown, who in a report of 100 cases found that 10 per cent occurred in negroes.

Reports on the incidence of acute perforation of peptic ulcer according to sex vary greatly. For example, in 645 cases collected from the literature by Moynihan in 1901, 26.9 per cent of cases occurred in females. On the other hand, Eliason and Ebeling, in 1934, collected 2,630 cases from the literature wherein the frequency in females was as low as 3.2 per cent. In 934 cases reported by 10 authors between 1910 and 1934 the frequency of perforation in females was 7.17 per cent.

Reports in the literature indicate that acute perforation of peptic ulcer occurs at all ages. Butka reported a case in an infant aged 4 days, and Finny reported one in a child aged 2 months. Jirasek and Persky, Robinson and O'Flyn have reported instances in children aged 7, 12, and 14 years, respectively. In his series of 387 cases, Dunbar reported 6 per cent as having occurred in patients between 12 and 20 years of age. With reference to the frequency of perforation in adults, Poole and Dineen found that 90 per cent of their cases occurred between the third and fifth decades. Eliason and Ebeling, Rhodes and Collins, Dunbar, and Hinton have reported cases in

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patients aged 71, 72, 74, and 80 years, respectively.

Concerning social status and occupation, Rhodes and Collins reported that in their series acute perforation of peptic ulcer occurred in persons in the lower social scale who observe poor hygienic and dietary habits. In Robitshek's series, 32 per cent of patients were laborers, whereas in Shelly's group 10 per cent were chauffeurs.

Apparent seasonal variations in the symptoms of peptic ulcer have been reported repeatedly. It is commonly taught that symptoms are more marked in the spring and fall than in the summer and winter seasons. In Hinton's series of 105 cases, 44.7 per cent of perforations occurred in the months of March, April, October, and November. In Eliason and Ebeling's series, 32.4 per cent occurred in October, November, and December. Rhodes and Collins reported that in 70 per cent of their cases perforation occurred in the 6 month period constituting winter and spring. In Dunbar's series the largest number of perforations occurred in January and the next largest in March and July.

The question of the existence and duration of the symptoms of peptic ulcer prior to perforation is an interesting feature of this complication of the disease. In a report on the diagnostic symptoms and signs in this same group of 500 cases, I pointed out that symptoms characteristic of peptic ulcer preceded acute perforation in 76.1 per cent. Eliason and Ebeling reported that in 27 per cent of their cases symptoms had existed for less than 6 months whereas in 18.9 per cent of cases symptoms had persisted for 5 or more years. Moreover, in 48.2 per cent of their cases medical treatment had been employed prior to perforation.

Held and Goldbloom state that the frequent location of peptic ulcer on the anterior wall of the duodenum is the most significant fact in the frequency of perforation and is the reason that perforation of duodenal ulcer is more frequent than perforation of gastric ulcer. In the cases of Eliason and Ebeling over 80 per cent of perforations were on the anterior surface of the first portion of the duodenum. Of their gastric ulcers, 50 per cent were situated on the anterior surface of the pylorus. In the cases of Jirasek and Persky, 30 per cent of perforations of gastric ulcer occurred through the anterior wall whereas 90 per cent of the duodenal ulcers were situated anteriorly.

Possible exciting causes mentioned in the literature on acute perforation of peptic ulcer are alcohol, physical exertion, food, foci of infection, trauma, and manipulation incidental to fluoroscopic examination with the barium meal. Troutt expressed his belief that excessive smoking and the consumption of impure alcoholic beverages contributed to the high incidence of perforation in American soldiers in Hawaii. Rhodes and Collins observed that perforation in many of their cases occurred after excessive indulgence in alcohol or food and that the majority bore evidence of poor oral hygiene. Despite the fact that perforation in many of their cases occurred while the patients were undergoing physical exertion, the cases were not held compensible under California law.

Colp concluded that sudden physical effort and distention of the affected viscus by food or otherwise are factors in causing sudden rupture of penetrating ulcers. In 6 of their cases, Eliason and Ebeling obtained evidence of the recent ingestion of food. Corlette analyzed the causes of perforation from the standpoint of pure physics. He pointed out that a general increase in pressure within the abdominal cavity, as by contraction of muscles of the abdominal wall, cannot cause perforation because the increase in pressure is the same within as without the hollow viscera. Contraction of the muscle in the walls of a diseased viscus, on the other hand, can produce an inequality of pressure within over that without the viscus, which, if it passes the bursting strain of the floor of the ulcer, will cause acute perforation. He stated, moreover, that external force exerted against the wall of the viscus adjacent to an ulcer can cause it to stretch and thereby rupture. Powers reported 3 cases wherein trauma was believed to be an etiological factor in acute perforation. Morrow reported 5 cases of perforation of the duodenum or stomach after trauma, in some of which chronic peptic ulcers apparently existed previously. His report is

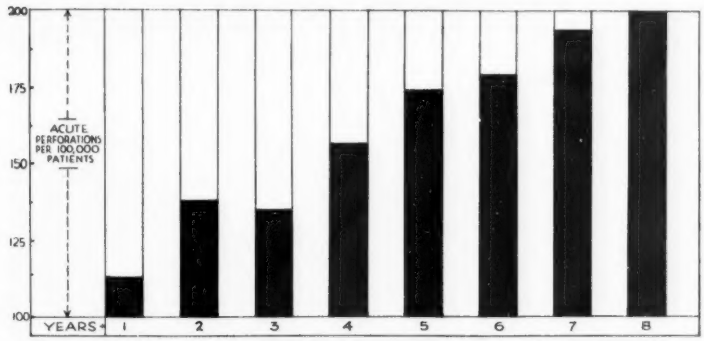

Fig. 1. Graphic presentation of the increase in incidence in hospital patients of acute perforation of peptic ulcer during the 8 year period beginning July 1, 1925, and ending June 30, 1933. In 100,000 hospital patients there were 167 acute perforations of peptic ulcer. In 1,958 diagnoses of peptic ulcer there were 385 acute perforations. Average yearly incidence (8 year period) 19.6 per cent; increase in 8 year period, 78.5 per cent.

of interest because under Minnesota law compensation was allowed in 4 of the 5 cases.

Singer collected 34 cases from the literature and reported 4 additional cases wherein acute perforation followed soon after fluoroscopic examination of the stomach and duodenum. The manipulation of tissues incidental to examination was believed to be the exciting cause of acute perforation in these cases.

METHOD OF STUDY

The present study was conducted on the clinical records of the cases of gastric and duodenal ulcer complicated by perforation which were observed at the Los Angeles County General Hospital between September 9, 1921, and June 30, 1934. There were 500 cases observed during this period in which the clinical features were manifest in the acute form. In 491 cases the diagnosis of perforated peptic ulcer was confirmed by operation or autopsy. In 9 cases, comprising the small minority of 1.8 per cent, the history and physical findings were so typical as to exclude any reasonable doubt concerning the clinical diagnosis. Cases in which any doubt existed regarding the diagnosis were not included in this study. The important contributory and exciting etiological factors obtained from the clinical notes on each case were tabulated for study so that numerical and percentage values could be placed on them. The study was conducted with one important point constantly in mind, namely, the distinction between the causes of peptic ulcer *per se* and the causes of complicating acute perforation of peptic ulcer. The latter is the primary concern of this paper.

RESULTS

Incidence of acute perforation of peptic ulcer. In the period beginning on July 1, 1925, and ending on June 30, 1933 (the dates between which complete hospital records on incidence were available), there were 229,352 in-patients admitted to the Los Angeles County General Hospital (Table I). Among them there were 385 cases of acute perforation of peptic ulcer comprising an incidence of 167 per 100,000 of hospital patients. During the 8 year period

TABLE I.—YEARLY INCIDENCE OF ACUTE PERFORATION OF PEPTIC ULCER PER 100,000 HOSPITAL IN-PATIENTS DURING THE 8 YEAR PERIOD FROM JULY 1, 1925, TO JUNE 30, 1933, INCLUSIVE

Year	Number of in-patients	Number of perforations	Incidence of perforations per 100,000 patients
1925–1926	20,528	23	112
1926–1927	23,139	32	138
1927–1928	25,451	34	133
1928–1929	25,897	41	158
1929–1930	27,941	40	175
1930–1931	32,528	59	181
1931–1932	35,453	70	197
1932–1933	38,415	77	200
Total	229,352	385	Aver. 167

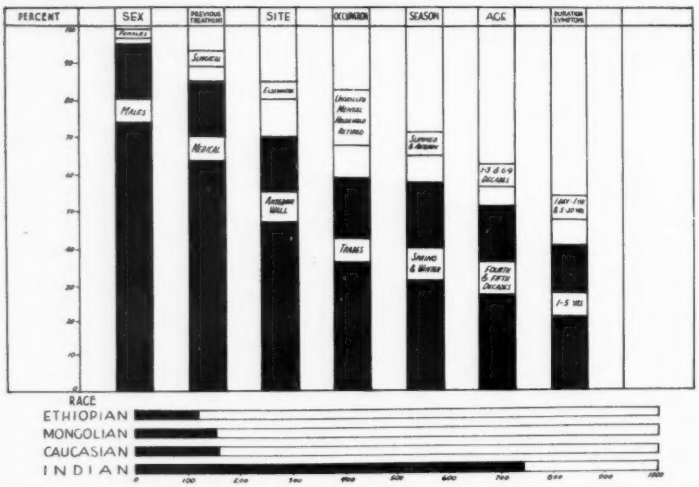

Fig. 2. Graphic presentation, expressed in percentage of cases wherein recorded, of the relative importance of contributory etiologic factors in acute perforation of peptic ulcer. The data on race are expressed in terms of number of cases per 100,000 patients.

under consideration, the yearly incidence rose from 112 to 200 per 100,000 patients or an increase during the period of 78.5 per cent (Fig. 1). During the same period there were in the hospital 1,958 patients in whom the diagnosis of peptic ulcer was made, including the 385 cases of perforated peptic ulcer (Table II). The yearly proportion of acute perforations among these patients ranged from 13.8 to 30.5 with an average of 19.6 per cent. Whereas the incidence of acute perforation of peptic ulcer was 1.67 per thousand hospital patients the proportion of perforations in peptic ulcer patients was nearly 1 in 5.

TABLE II.—YEARLY PERCENTAGE OF ACUTE PERFORATION IN HOSPITAL DIAGNOSES OF PEPTIC ULCER DURING THE 8 YEAR PERIOD FROM JULY 1, 1925, TO JUNE 30, 1933, INCLUSIVE

Year	Number of diagnoses of peptic ulcer	Number of acute perforations of peptic ulcer	Percentage of perforations in peptic ulcer diagnoses
1925–1926	132	23	17.4
1926–1927	173	32	18.4
1927–1928	252	34	13.8
1928–1929	266	41	15.4
1929–1930	234	49	20.9
1930–1931	287	59	20.5
1931–1932	229	70	30.5
1932–1933	385	77	20.0
Total	1958	385	Aver. 19.6

Contributory etiologic factors. A comparison of the relative importance of the several contributory etiologic factors is shown in Figure 2.

Race. Covering the period between July 1, 1928, and June 30, 1934, hospital records relative to the number of in-patients according to race and sex were available (Table III). Among 211,309 Caucasian patients there were 332 cases of acute perforation of peptic ulcer, comprising an incidence of 157 per 100,000. The incidence among Indians was 746, among Mongolians 156, and among Ethiopians (negroes) 121.

Sex. During this period there were 106,389 male and 102,431 female in-patients in the hospital (Table IV). There were 341 acute perforated peptic ulcers in males and 16 in females. The sex incidence per 100,000 hospital patients, therefore, was 320 among males and 15 among females. In the entire series of 500 cases of acute perforation of peptic ulcer the incidence in males and females was 94.2 and 5.8 per cent, respectively.

Age. In this series of 500 cases there were no acute perforations in the first decade of life (Table V). There were 10, comprising 2 per cent of cases, in the second decade. In the fourth and fifth decades combined, there were 262 cases representing 52.2 per cent. In the

TABLE III.—INCIDENCE PER 100,000 PATIENTS OF ACUTE PERFORATION OF PEPTIC ULCER ACCORDING TO RACE DURING THE 6 YEAR PERIOD FROM JULY 1, 1928, TO JUNE 30, 1934, INCLUSIVE

Race	Number of in-patients	Number of perforations	Incidence of perforations per 100,000 patients
Indian	134	1	746
Caucasian	211,309	332	157
Mongolian	1,280	2	156
Ethiopian (negro)	14,046	17	121

TABLE IVA.—INCIDENCE PER 100,000 PATIENTS OF ACUTE PERFORATION OF PEPTIC ULCER ACCORDING TO SEX DURING THE 6 YEAR PERIOD FROM JULY 1, 1928, TO JUNE 30, 1934, INCLUSIVE

Sex	Number of in-patients	Number of perforations	Incidence of perforations per 100,000 patients
Male	106,389	341	320
Female	102,431	16	15

TABLE IVB.—PERCENTAGE OF SEX INCIDENCE IN THE GROUP OF 500 CASES

Sex	Total number of acute perforations of peptic ulcer	Percentage of perforations according to sex
Male	471	94.2
Female	29	5.8
Total	500	100.0

decades next younger and next older, namely, the third and sixth combined, there were 164 cases or 32.8 per cent. In other words, 85.0 per cent of cases occurred in the third to sixth decades, inclusive. In the seventh, eighth, and ninth decades 8.0, 4.4, and 0.6 per cent of cases, respectively, were represented.

Occupation. The occupations of the patients were recorded in 453 cases (Table VI). Retired persons comprised 1.5 per cent and household workers, including housewives, 4.4 per cent. Unskilled workers composed 15.4 per cent of cases. This group was slightly outnumbered by mental workers, business executives, and professional people combined, who constituted 19.8 per cent of cases. The largest group was composed of skilled tradesmen who comprised 58.7 per cent of cases.

Month and season. There was an appreciable variation in the monthly occurrence of acute perforation of peptic ulcer (Table VII). Whereas from October through May there was a monthly incidence of from 40 to 58 cases, the incidence from June through September was from 28 to 34. The seasonal incidence was lowest in summer, being 18.6 per cent; highest in spring at 30.4 per cent; with 23.2 and 27.8 per cent in autumn and winter, respectively.

TABLE V.—AGE DISTRIBUTION OF 500 CASES OF ACUTE PERFORATION OF PEPTIC ULCER

Age, years	Number of perforations	Percentage of perforations
1–10	0	0.0
11–20	10	2.0
21–30	85	85.0*
31–40	131	
41–50	130	
51–60	79	
61–70	40	8.0
71–80	22	4.4
81–90	3	0.6
Total	500	100.0

*Percentage in third and sixth decades combined 32.8. Percentage in fourth and fifth decades combined 52.2.

TABLE VI.—INCIDENCE OF ACUTE PERFORATION OF PEPTIC ULCER IN 453 CASES ACCORDING TO OCCUPATION

Classes of occupations	Number of perforations	Percentage of perforations
Unskilled	70	15.4
Trades (skilled)	266	58.7
Household	20	4.4
Mental work	64	19.8
Professional–Executive	26	
Retired	7	1.5
	453	
Not recorded	47	
Total	500	100.0

TABLE VIIA.—MONTHLY INCIDENCE IN 500 CASES OF ACUTE PERFORATION OF PEPTIC ULCER

Month	Number of perforations	Month	Number of perforations
January	51	July	28
February	44	August	31
March	58	September	33
April	46	October	40
May	47	November	47
June	34	December	41
Total			500

TABLE VIIB.—SEASONAL INCIDENCE IN 500 CASES OF ACUTE PERFORATION OF PEPTIC ULCER

Season	Number of perforations	Percentage of perforations
Spring	152	30.4
Summer	93	18.6
Autumn	116	23.2
Winter	139	27.8
Total	500	100.0

TABLE VIII.—DISTRIBUTION OF 303 ACUTE PERFORATIONS OF PEPTIC ULCER ACCORDING TO DURATION OF SYMPTOMS

Duration	Number of perforations	Percentage of perforations
1–30 days	23	7.6
1–12 months	44	14.5
1–5 years	124	41.0
5–10 years	66	
10–15 years	20	32.7
15–20 years	13	
20 or more years	13	4.2
	303	
Not recorded	197 (39.4%)	
Total	500	100.0

TABLE IX.—INCIDENCE OF ACUTE PERFORATION OF PEPTIC ULCER IN 89 PREVIOUSLY TREATED CASES

Treatment	Number of perforations	Percentage of perforations
Medical	76	85.4
Surgical	13	14.6
Total	89	
Not recorded	411	
Total	500	100.0

Duration of symptoms. The duration of symptoms of peptic ulcer prior to perforation was recorded in 303 cases (Table VIII). Of these cases, 7.6 per cent of patients had noted symptoms for 1 month or less. In 14.5 per cent of cases, symptoms had been present for from 1 to 12 months; in 41.0 per cent, from 1 to 5 years; in 32.7 per cent, from 5 to 20 years; and in 4.2 per cent, for over 20 years.

Previous treatment. In 89 cases treatment for peptic ulcer had been instituted prior to perforation (Table IX). Of these 85.4 per cent had had medical treatment whereas 14.6 per cent had been treated surgically.

Site of perforation. The site of the perforation was recorded in 483 cases (Table X). In 69.0 per cent, the perforation was situated on the anterior wall of the stomach or duodenum. In 27.6 per cent of the cases, it was situated elsewhere.

Exciting causes. Several factors which have been mentioned as exciting causes of acute perforation of peptic ulcer were recorded in 147 cases (Table XI, Fig. 3). In 7.5 per cent of these cases the patients had drunk some form of alcoholic beverage and an additional 24.5 per cent had taken food within 1 hour prior to the onset of the symptoms of perforation. In 59.0 per cent of cases the patients were undergoing physical exertion at the time

TABLE X.—INCIDENCE OF ACUTE PERFORATION IN 500 CASES OF PEPTIC ULCER

Site	Number of perforations	Percentage of perforations
Anterior wall	345	69.0
Elsewhere	138	27.6
Not recorded	17	3.4
Total	500	100.0

perforation occurred. On the other hand, 39 patients were either asleep or at rest when perforation took place. If, like exertion, rest could be conceived of as an exciting cause of perforation the comparative percentages of cases would be 46.7 and 20.9 per cent, respectively. In 2.8 per cent of cases each, external trauma and recent x-ray examination with the opaque meal seemed to be factors which excited acute perforation. The combination of alcohol and exertion was present in 2 cases or 1.3 per cent whereas food in combination with either exertion, sleep, or alcohol each were present in 1 or 0.7 per cent of cases.

ANALYSIS AND EVALUATION OF DATA

Incidence of acute perforation

An analysis of the data which are herein presented disclosed some interesting and significant facts on the incidence and increasing importance of acute perforation of peptic ulcer (Fig. 1). During the 8 year period ending on June 30, 1933, considerable variation in the yearly number of diagnoses of peptic ulcer is manifest. The proportion of acute perforations also varies from year to year but an average for the period of approximately 20 per cent is maintained. The increasing importance of acute perforation generally as well as in the hospital is indicated by the fact that per 100,000 patients, the incidence has risen from 112 to 200. This represents an increase in 8 years of 78.5 per cent. As the most common cause of death in peptic ulcer these figures show a striking similarity to the mortality statistics from 1900 to 1933, as reported by Rice for the Department of Health of New York City.

Contributory etiological factors

Race. The data on the racial incidence of acute perforation reveal several points of interest. The number of Caucasian and Ethiopian patients is sufficient to give an accurate indica-

TABLE XI.—FREQUENCY OF POSSIBLE EXCITING FACTORS IN 147 CASES OF ACUTE PERFORATION OF PEPTIC ULCER

Exciting factors	Number of cases	Percentage of cases
Alcohol	11	7.5
Food	36	24.5
Exertion	87	59.0
Trauma	4	2.8
X-ray examination	4	2.8
Alcohol and exertion	2	1.3
Food and exertion	1	0.7
Food and alcohol	1	0.7
Food and sleep	1	0.7
Sleep	39 (20.9%)	
Not recorded	314	
Total	500	100.0

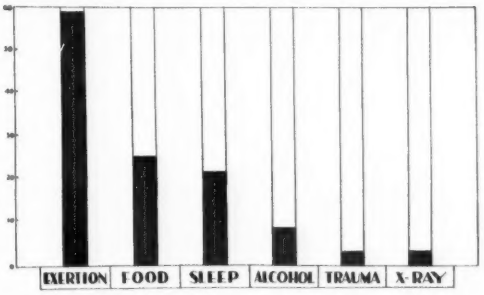

Fig. 3. Graphic presentation, expressed in terms of percentage of cases wherein recorded, of the relative importance of the so called exciting etiologic factors, in acute perforation of peptic ulcer.

tion of the incidence of acute perforation in these races. It is of interest, therefore, to note that in this series the incidence in the negro is 23 per cent lower than in the white race. The number of Indian and Mongolian patients is much smaller but the data are of interest chiefly because the frequency per 100,000 in Mongolians is only 1 case less, whereas in Indians it is 4¾ times greater than in Caucasians.

Sex. One of the most striking features of peptic ulcer is the marked difference in sex incidence. The findings of this study confirm those of previous studies relative to the marked preponderance of males among the afflicted. The occurrence of acute perforation in males in over 94 per cent of cases strongly indicates some constitutional factor at play which as yet remains unidentified.

Age. While the age occurrence of acute perforation of peptic ulcer represented in this study covers the broad span of 90 years, exclusive only of the first decade, the case frequency in the different decades exhibits distinct zones of demarcation. The data indicate clearly that acute perforation of peptic ulcer is distinctly a disease of adult middle life. For example, there were nearly 6 times as many cases in the four decades from the third through the sixth as in the 5 remaining decades. There were over 8 times more cases in the third decade than in the second and about twice more in the fourth than in the third. After the fifth decade the number of cases in each succeeding decade fell off by about 50 per cent per decade.

Occupation. Until data relative to total hospital admissions according to occupation are available only relative estimates of the incidence of acute perforation of peptic ulcer in the various occupations can be made. In 3 of the 6 classes other contributing factors enter into consideration. For example, the factor of age must be taken into consideration as a partial explanation of the low incidence in the retired group. Similarly, with respect to the professional-executive group, economic and social factors are of importance and in the household workers group, sex is an important factor. Of the 3 remaining groups it appears to be of significance that the incidence of perforation is about the same in the unskilled as in the mental workers, whereas nearly 60 per cent of the entire series of cases belongs to the trades or skilled worker's group. The latter facts appear to ignore social and economic factors somewhat. Moreover, they are not quite in keeping with the observations of Rhodes and Collins (whose cases were collected from a comparable source, namely, the emergency surgery service of the city of San Francisco. The majority of these patients belonged to the lower social strata).

Month and season. It will be recalled that there were slight variations in the frequency of acute perforation from month to month throughout the year. Starting from a low point in July, the incidence gradually rose with slight recessions through November and January, reaching the highest point in March and falling off sharply thereafter. While there were a great number of cases in spring and autumn over the number in summer, a recession in winter, as is commonly taught, was not observed.

Duration of symptoms. The duration of symptoms was not recorded in 197, or 39.4 per cent of cases. In my communication on the diagnostic symptoms and signs in this series of cases, I pointed out that 81 cases were not interrogated regarding a previous history of ulcer. Deducting the latter from the former group there are left 116 cases, or 23.2 per cent, of the 500 cases in which presumably the symptoms were so brief or so mild as to be unworthy of recollection or of record. Among the remaining 303 cases, the 41 per cent of patients, in whom symptoms had existed for from 1 to 5 years, might reasonably be expected to have gained sufficient knowledge of peptic ulcer as to cause them to observe certain precautions against perforation. Of the remaining 59 per cent of patients, those in whom the symptoms had existed from 1 day to 12 months, the duration probably was so brief or transitory that many of the patients could reasonably be excused for their lack of appreciation of the significance of their disease. The patients in whom the chronicity had persisted for a period of time covering from 5 to 20 or more years may have grown careless of their observance of health programs.

Previous treatment. While acute perforation took place in 89 previously diagnosed and treated patients, it is not within the scope of this paper to formulate of any conclusions concerning the adequacy of either medical or surgical treatment. The chief point to be learned, however, is that the number of perforations in previously treated patients is sufficiently large to emphasize the fact that in any patient with peptic ulcer, either treated or untreated, the possibility of acute perforation is a constant threat to the life and health of its bearer.

Site of ulcer. That the situation of peptic ulcer on the anterior wall of the stomach or duodenum is an important factor predisposing to acute perforation is amply attested to by the fact that this condition obtained in 69 per cent of the cases which comprise this study. It, however, does not bear out the statement made by Held and Goldbloom, that it is the single most important factor in acute perforation.

Exciting causes

So long as the lack of knowledge of a specific cause of peptic ulcer exists, the conception of exciting causes of acute perforation will remain debatable. However, the mere coincidence of certain factors with acute perforation in so large a number as 147 cases demands a certain degree of recognition. Of the several factors mentioned, and ignoring the statistics for the moment, it appears, in view of the mechanics involved, that substances within, which are capable of distending the stomach or duodenum, such as food or drink, and forcible manipulation of the viscera, as in fluoroscopic examination, or possibly local trauma, are the most important exciting causes of acute perforation.

SUMMARY AND CONCLUSIONS

This study reveals certain facts concerning the relative importance of many factors which are believed to be exciting or contributory to acute perforation of peptic ulcer. Additional significance is given to the study by virtue of the large number of cases studied and because it represents the recent experience of the largest general hospital in the United States.[1]

The salient facts revealed are as follows:

1. During an 8 year period ending on June 30, 1933, the yearly incidence of acute perforation of peptic ulcer per 100,000 hospital in-patients has risen by 78.5 per cent.

2. The frequency of acute perforation among all cases diagnosed as peptic ulcer during the 8 year period was about 1 in 5.

3. The incidence of acute perforation per 100,000 Caucasian hospital in-patients was 157, whereas in Ethiopians (negroes) it was 23 per cent lower.

4. Acute perforation of peptic ulcer occurred in males in 94 per cent of cases.

5. Acute perforation of peptic ulcer occurred in every decade from the second through the ninth with 52.2 per cent of cases in the fourth and fifth decades combined.

6. Sixty per cent of the cases of acute perforation occurred in skilled trades people.

[1]The fifteenth annual 1936 presentation of hospital data by the Council of Medical Education and Hospitals of the American Medical Association specifies beds, rated capacity as follows: Los Angeles General Hospital, Los Angeles, 3,266; Cook County Hospital, Chicago, 3,150; King's County Hospital, Brooklyn, 3,040; Philadelphia General Hospital, Philadelphia, 2,500; Bellevue Hospital, New York City, 2,313.

7. The highest number of perforations occurred in March and the lowest in July. Correspondingly, the greatest number occurred in the spring and the least in the summer.

8. The duration of symptoms ranged from less than 1 month to 20 years or over, with the greatest number of cases in the 1 to 5 year group.

9. Acute perforation occurred in 89 cases which previously had been diagnosed and treated by medical or surgical methods.

10. In 69 per cent of cases the perforation occurred on the anterior wall of the stomach or duodenum.

11. Of the so called exciting causes of peptic ulcer the greatest number occurred while the patient was undergoing physical exertion.

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LYMPHATICS IN OMENTAL ADHESIONS

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THE fact that the omentum forms adhesions rapidly with other abdominal viscera upon irritation is generally recognized. The importance of such adhesions in the repair of intestinal injuries has been emphasized by Clark, Neuhof and Wiener, Richardson, Hertzler, Corbett, Fenton and Peet, Rothschild, Bothe, Figurelli, and others. The studies of Hertzler on the genesis of peritoneal adhesions are most extensive. Other investigators have been concerned chiefly with the question of the participation of blood vessels in the formation of adhesions. Senn believed that anastomoses were formed between hemal channels of the gut and omentum within 18 to 48 hours after chemical irritation of the intestine, and Gundermann observed that these vessels were persistent after a period of 3 months. Employing the injection method, Girolaff demonstrated conclusively the continuity of blood vessels from the intestine to the omentum. Springer, Asoh, and Stropeni, evidently unaware of Girolaff's experiments, used similar methods to reach the same conclusions. Histological studies of adhesions involving the intestine and omentum have yielded divergent interpretations. Bloomhardt, Andrews, and Hetherington were unable to demonstrate blood vascular anastomoses, but Kovàcs observed them 24 hours after operation. The figures of histological preparations presented by Asoh confirm their existence.

The behavior of the lymph vessels in omental adhesions has not received sufficient study. Indeed, the presence of omental lymphatics has been questioned frequently, but the recent works of Simer, Fischer, and Dick leave no doubt of the existence of these channels. The last named investigator became interested in this problem after observing that 2 patients were relieved of symptoms of elephantiasis by the establishment of postoperative adhesions between the subcutaneous tissue of the anterior body wall and the distal portion of the omental sac. He attempted, unsuccessfully, to demonstrate anastomoses of lymph vessels in experimental adhesions in the rabbit, but expressed the opinion that such connections actually exist. Braithwaite, Macguire, and other surgeons apparently concur in this belief. They have suggested a lymphatic connection by way of the adherent omentum in explanation of the common occurrence of gastric and duodenal ulcers and cholecystitis following inflammation of the appendix.

Our investigation deals with the study of newly formed lymph channels in experimental adhesions of the omentum and jejunum. Laparotomies were performed on dogs which were anesthetized with nembutal. In all animals, the mesenteric blood and lymph vessels of a small portion of jejunum were ligated 4 centimeters from the intestine. The serosa was irritated mechanically, and the distal portion of the omental sac was sutured to it. An additional suture was made involving the omentum and the mesentery in four instances. Postmortem examinations followed the operations at intervals of 6 to 17 days, and in 10 animals adhesions were studied. Subserosal and intramuscular injections of India ink were made in the jejunum near the omental adhesions, and, after gross examinations, tissue was selected for microscopic study. This material was fixed in 10 per cent formalin, embedded in paraffin, and sectioned serially 50 microns in thickness. Spreads of the omentum were made from regions in which the lymph vessels were delineated clearly as a result of the ink injections.

In successful attempts to demonstrate the continuity of the jejunal and omental lymphatics through the adhesions, ink was seen to pass from the ink bleb of the intestinal wall into the omental vessels and, eventually, to reach the duodenal or splenic nodes. From a study of omental spreads it was found that near adhesions, the periarterial plexuses of

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Fig. 1. An omental spread showing lymph vessels of the periarterial type, *P*, and the lateral type, *L*. The lymphatics contain ink which was injected into the intestinal wall near an adhesion of the jejunum and omentum. *A*, Artery; *V*, vein. The distal end of the omentum is at the bottom of the figure, and the arrow indicates the direction of lymph flow to the duodenal node.

omental lymphatics (Fig. 1, *P*) were filled with the injection mass. This was soon shunted to the lateral lymphatic channels (Fig. 1, *L*) which could be seen extending to the collecting nodes. Examination of serial sections made from tissue involved in the adhesion verified the lymphatic nature of these vessels.

In the course of study of an adhesion 14 days after the laparotomy, a graphic reconstruction was made (Fig. 2). By this method, it was possible to demonstrate clearly a connection between a lateral lymph channel of the adherent omentum with the serosal plexus of the jejunum. A photomicrograph of a section through the connecting vessel (Fig. 3, *L*) illustrates the continuity of the pathway of the injection mass between the two structures. Returning to a study of the reconstruction, it is evident in this case that the periarterial lymphatics could not be traced from the jejunum into the omentum; nor was it possible to see a blood-vascular junction. This may have its explanation in the penetration of these structures into the area of inflammation surrounding the catgut ligature, because it

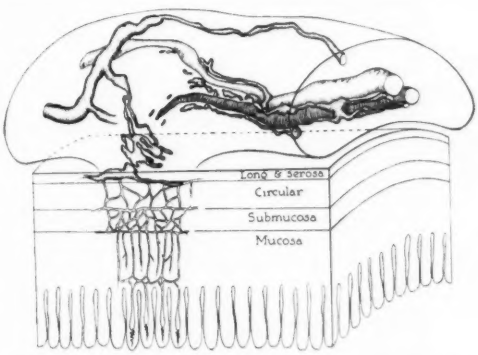

Fig. 2. Diagram showing the relation of a portion of the jejunum and omentum involved in an adhesion. The structures indicated by shading were reconstructed graphically. Lymphatics are indicated by stippling, and blood vessels by vertical lines. Subserosal vessels of the jejunum anastomose with a lateral lymphatic vessel. Periarterial lymphatics of the omentum could not be traced to their connection with the serosal lymphatics of the intestine. The layers of the intestinal wall and the schematic arrangement of the jejunal lymphatics are indicated.

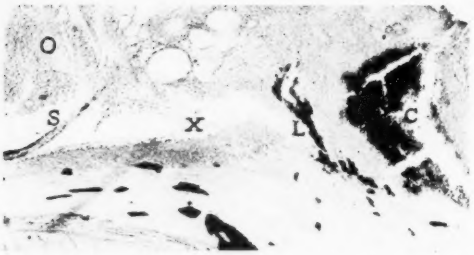

Fig. 3. A photomicrograph of a section of the adhesion shown in Figure 2. The omentum, *O*, is adherent to the jejunum at *X*, and the ink filled lymph vessel, *L*, is a part of the anastomosis between intestinal and omental lymphatics. The position of a ligature used in establishing the adhesion is shown by the cavity, *C*, partially filled with ink. A connective tissue strand, *S*, forms a part of the adhesion and contains anastomosing lymph vessels.

was difficult to discern the walls of the vessels. There can be no doubt, however, that anastomosis of blood vessels does occur. In some instances, the injected ink entered the veins of the jejunum instead of the lymph channels. When this occurred, the omental veins were colored quickly by the injection fluid. This finding confirms the observations of Girolaff.

The majority of investigators have been concerned chiefly with the intimate adhesions of the peritoneal surfaces, similar to the inflammatory area shown in Figure 3. Little attention has been paid to strands of tissue connecting the two surfaces. When small blocks of tissue are examined by means of the compound dissecting microscope, such strands are seen to be numerous near the region of most intimate contact and become fewer as the periphery is approached. The photomicrographs published by Fenton and Peet and by Figurelli show good examples of these connecting strands. They, evidently, considered them of little significance.

Following the injection of the jejunal lymphatics with India ink, many of the single strands of tissue connecting the jejunum and the omentum became colored. A study of serial sections through such a region revealed the fact that connecting lymphatic and blood vessels existed in them. Figure 4 illustrates this fact. The strand containing ink filled lymphatics is designated, *S*, and the line of juncture of the omentum and jejunum, *X*. A similar strand, magnified more highly, is shown in Figure 5. In this case, the lym-

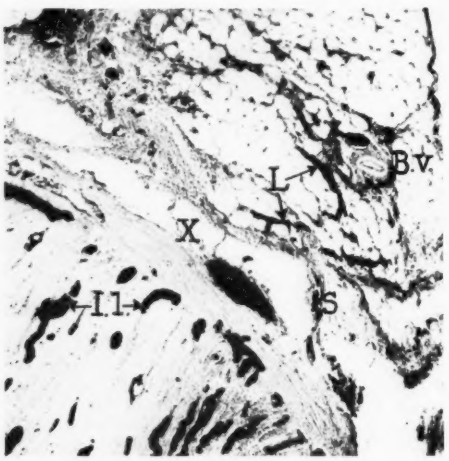

Fig. 4. Photomicrograph of a section of an adhesion involving the omentum and jejunum. Note the ink filled anastomosis of a subserosal intestinal lymphatic with those of the omentum by means of connective tissue strand, *S*. The line of adhesion is indicated by *X*; *L*, lymph channel of the omentum; *B.v.*, blood vessel in omentum; *I.l.*, lymph vessels in the subserosal and muscular layers of the jejunum.

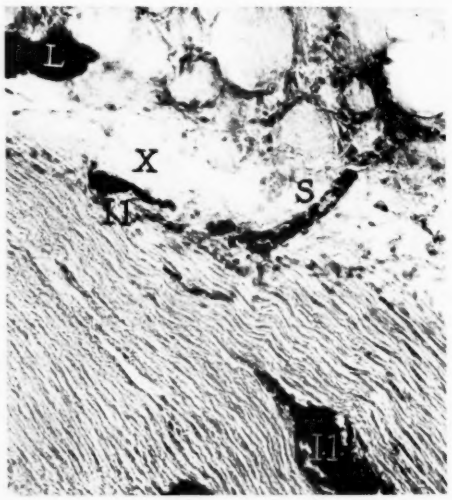

Fig. 5. A photomicrograph at higher magnification of a section through an adhesion of the jejunum and omentum. The line of adhesion is indicated by *X*. A connective tissue strand, *S*, contains an ink filled lymph vessel which connects the lymphatics of the intestine and omentum. *L*, Omental lymph channel; *I.l.*, lymph vessels of the subserosal and muscle layers of the jejunum.

phatic bridges completely the line of adhesion. Connections of these lymphatics with the periarterial lymphatics of the omentum could be traced through the series of sections. The photomicrographs depict the arrangement of lymphatic vessels found in an animal 15 days after operation.

Postmortem examinations were made on dogs at varying intervals after the operation to determine the minimum time necessary for the establishment of lymphatic anastomoses. Such connections could not be demonstrated in a 6 day adhesion, but they were observed readily in those of 8 days or more. The union of the lymph channels of adherent organs is a progressive growth; for in the well developed adhesion of 17 days, ink passed from the intestinal lymph vessels to those of the omentum with greater rapidity than in newer adhesions.

CONCLUSION

This study shows that lymphatic connections are established between the jejunum and omentum after experimental adhesions have been induced. Injections with India ink show that these anastomoses are formed as early as 8 days after operation.

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THE SYNDROME OF CONGENITAL ABSENCE OF THE FIBULA

Report of 3 Cases with Special Reference to Pathogenesis and Treatment

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TEXT books on orthopedic surgery do not contain an adequate conception of the mechanism of formation of a common deformity of the lower limb, usually referred to under the title of congenital absence of the fibula (1, 48). The present state of knowledge of embryology has advanced beyond surgical comprehension of this deformity. Recently, the authors have encountered 3 cases of this syndrome in different stages of development. A study of these cases in comparison with the methods of treatment recommended in the literature shows that many of these methods are physiologically unsound. It is probable that no one type of treatment can be applied to all cases as the indications for interference vary with the stage of neglect of the condition, the age of the patient, and associated deformities.

That the condition is not rare is indicated by the recent report of Lapasset and Cahuzac who found 295 cases in the literature prior to their report of 1 bilateral case. These authors state that such a deformity occurs once in 3,000 instances of all surgical conditions admitted to the hospital. In this report we will not attempt to review all the cases in the literature as this has already been adequately done (9, 11, 15, 23, 31, 32, 42). We wish to describe the deformity in detail with special reference to anatomic facts revealed by dissection and roentgenology. In all of our 3 cases, as well as in the cases in the literature, certain developmental trends are seen. These will be pointed out later.

EMBRYOLOGY

The origins of such a defect must occur during or previous to differentiation of the scleroblastema of the limb bud in the embryo. A clear account of the early formation of the anlage for the limbs is given by Bardeen and Lewis, which may be summarized as follows:

During the second half of the third week of fetal life there occurs an especially marked thickening opposite the twenty-first to the twenty-sixth spinal myotomes. This shortly differentiates into the limb bud. From the basal portion of each limb bud are developed the limb girdle and thigh. From the distal part are developed forelimb and foot. The scleroblastema, or skeletal anlage, is already present in the sixth week of fetal life. In this, the cartilaginous skeleton is differentiated and this in turn is replaced by the osseous skeleton. It is not clear whether the anlages of the tibias and fibulas begin as separate sheets which become divided. In an 11 millimeter embryo the blastemal anlages are differentiated but not quite completely divided. In an embryo of 16 to 18 millimeters the tibia and fibula are quite separate. By the seventh week the skeletal structure in the posterior limb has undergone extensive differentiation. The rudiments of all the bones of the leg may be seen in the form of cartilage except the terminal phalanges of the three outer toes which have not yet appeared. The musculature of the posterior limb is so far differentiated that all muscles can be distinguished except the lumbricales. From this brief account of the early development of the skeleton in the limb bud it can be seen that the defect could be recognized anatomically as early as the fifth week of fetal life. This implies a very early and fundamental origin of the defect.

REPORT OF CASES

CASE 1. Male, aged 4 years, was seen at the University of Chicago Clinics in April, 1931, with deformities of both feet. These had been present since birth but had not yielded to cast applications which had been prescribed elsewhere. The physical examination was normal except for the appearance of both lower limbs below the knees (Fig. 1). Both legs were abnormally short and bowed anteriorly. A

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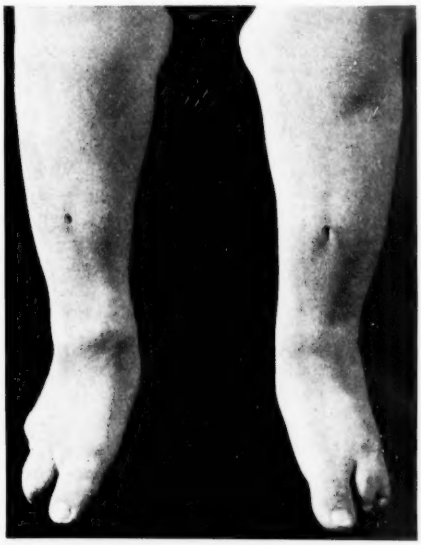

Fig. 1. Case 1. Appearance of patient's lower extremities upon admission to the hospital at the age of 4 years. Note the foot deformities and dimpling of the skin over the anterior tibial surface.

dimple was present on the anterior surface of each leg at the junction of the middle and lower thirds at the region of greatest bowing. Both feet were in equinus and slight valgus. Both great toes appeared normal. On the left foot, two other well defined but syndactylic and shortened digits were present. On the other foot, one broad deformed digit was present in addition to the great toe. On the lateral side of this same foot, midway anteriorly and posteriorly, a small hardened tissue bud could be seen.

Roentgenograms (Fig. 2) showed, on this same date, the bowing of the tibias noted in the physical examination, total absence of both fibulas and of an osseous center for both lower tibial epiphyses. On the left side, the ossific center for the calcaneus, astragalus, and cuboid were present, the latter two much smaller than normal for this age. The astragalus appeared to be fused with the os calcis. Three normally developed metatarsals were present with their corresponding digits. On the right side, the tarsals were not as well defined as on the left. The ossific center for the astragalus on this side was very small and separate from the os calcis. Three well defined metatarsals were present. Corresponding phalanges of the great toe appeared normal but only one set of phalanges was present distal to the other two metatarsals.

Because of the fact that the os calcis was riding on the posterior surface of the tibia and such adaptive contractures of the tendo achillis and other

Fig. 2. Case 1. Roentgenograms of the tibias and feet of patient shown in Figure 1, when first seen. The calcaneus is displaced posteriorly in both feet.

soft parts were present, operative interference was carried out on April 4, 1933. Tendo achillis length-

Fig. 3. Case 1. Appearance 2 years after operative correction of feet. Satisfactory weight bearing alignment is present.

Fig. 4.

Fig. 5.

ening was done on both sides. Even after the peroneus longus was lengthened and the peroneus brevis was sectioned on each side, it was necessary to open the capsule widely to shift the os calcis and the largely cartilaginous astragalus to the inferior articular surface of the tibia. The incisions were closed and boot casts were applied for 6 weeks to maintain correction. This was followed by bracing.

The patient did not return at regular intervals to the out patient department. About 40 per cent of the correction obtained on the right foot was lost in the next 5 months so that it was again necessary to open the right ankle joint laterally on October 4, 1933. On this occasion, the length of the right tendo achillis was found sufficient but it was necessary to sever the joint capsule and the external lateral ligaments again to place the astragalus and os calcis beneath the right tibia. On this occasion, cast immobilization with weight bearing was carried out for 3 months. Corrective shoes were then given the patient to force the feet into varus. During the following 2 years the patient was carefully supervised and the deformity did not lapse. Growth has been equal on the two sides.

Figure 3 shows this patient's feet, 2 years after operative correction. Roentgenograms were also

Fig. 6.

Figs. 4, 5, and 6. Case 1. Roentgenograms of the feet taken on the same date as Figure 3, 2 years after operation. Note the lower tibial epiphysis present in bone and the calcaneus and astragalus fused into one osseus mass in both feet.

made at this time and these are reproduced in Figures 4 to 6, inclusive.

Interesting alterations have occurred when these figures are compared with the original roentgenogram (Fig. 2). Practically all of the anterior bowing of the tibia has disappeared. An osseous center is now present for both tibial epiphyses but is much smaller than the average size for a 6 year old child. The calcaneus is well developed but the astragalus is now fused to the former bone on both sides. A pseudo-epiphysis (7, 8, 41) has appeared at the distal end of both first metatarsals. In this instance both pseudo-epiphyses were far better defined than in most of the cases reported in the literature (8, 39). The other two metatarsals were normal but on the right foot there was an abortive metatarsal that projected into the small skin bud. Three small tarsi are now present in each foot. The child still has (at 8 years of age) a cosmetic disability because of the relative shortening of the legs in comparison with the thighs. The feet are in good weight bearing position and the child walks and plays without any limp. He now wears normal shoes.

CASE 2. Male, was referred to the authors for orthopedic treatment at the age of 11 months. When first seen in March, 1935, the deformity of the left foot had been increasing for several months

Fig. 7.

Fig. 8.

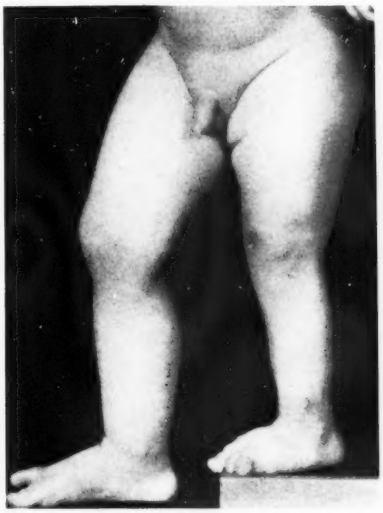

Fig. 9.

Fig. 7. Case 2. Appearance of foot deformity of patient at age of 11 months.

Fig. 8. Case 2. Roentgenogram taken at the age of 11 months. Note that there is no ossification in the lower tibial epiphysis and that the center for the astragalus has not yet appeared.

Fig. 9. Case 2. Appearance of patient at the age of 20 months, 8 months after operative correction of the foot.

even though there had been no weight bearing. Physical examination revealed a normal healthy child except for the deformity of the left leg and foot (Fig. 7). The left leg was 1¼ inches (3.2 centimeters) shorter than the right and was slightly less in circumference. The fibula could not be palpated. The foot was in a position of equinus and marked valgus. The ankle joint was relaxed. Three well formed and externally normal digits were present. Roentgenograms of the left leg and foot (Fig. 8) at this time showed slight anterior bowing of the left tibia. The fibula was absent. The distal epiphysis of the tibia was not present in bone. Only two centers of ossification in the tarsi could be seen, those for the calcaneus and for the cuboid. Three metatarsals with their corresponding digits were present. Although partial correction could be obtained by casts, the deformity always recurred within a few hours after removal. On April 9, 1935, operation was carried out. The structures on the lateral side of the ankle joint were exposed. The external lateral ligaments were cut. One peroneal tendon and the tendo achillis were found taut. Both were lengthened. A second peroneal tendon could not be found. The corrected position was maintained by a cast for the following 3 months during which time the child learned to walk. A brace was then fitted to prevent lateral deviation of the foot, and this he has worn since. Figure 9 shows the patient 8 months after operation. The foot deformity has not lapsed. X-ray pictures were made at this time (Figs. 10 and 11). Measurements of teleoroentgenograms showed the same discrepancy as originally present in length of the lower extrem-

Fig. 10, left. Case 2. Teleoroentgenograms of the tibias of patient at the age of 20 months. Note that there has been as much growth at the lower and upper tibial epiphyseal lines on the left side as on the normal right side. Transverse marking produced by phosphorized cod liver oil.

Fig. 11. Case 2. Lateral view of tibia and foot of patient at the age of 20 months. The lower tibial epiphyseal ossification center has just appeared.

Fig. 12.

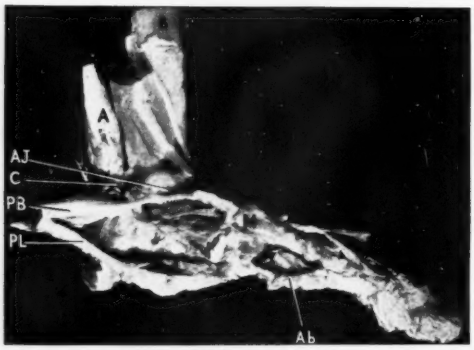

Fig. 15.

Fig. 12. Case 3. Appearance of patient at the age of 8, when first seen. Amputation was not performed until 2 years later.

Figs. 13 and 14. Case 3. Roentgenograms of the foot and leg of this patient. These films were taken at the same time as Figure 12. Note the anterior bowing of the tibia, which is still present. The tarsal bones have fused into one block.

Fig. 13. Fig. 14.

Fig. 15. Case 3. Photograph of the amputated foot of patient shown in Figure 12. *A*, Fibular remnant containing bone island. *B*, Tibia, *C*, Fibrous band, extending from the inferior surface of the fibular remnant to the calcaneus. *Aj*, Ankle joint. *PB* and *PL*, Peroneus brevis and peroneus longus tendons. *M*, Base of the most lateral (V) metatarsal. *Ab*, Abductor digiti quinti.

ities, 1½ inches (3.8 centimeters), ¼ inch (0.6 centimeter) being due to shortening of the femur. The patient had received phosphorized cod liver oil during his 2 months' stay in the hospital. As a result phosphorus lines were seen in all the metaphyseal regions being especially notable in the long bones. Measurements of the teleoroentgenograms (Fig. 10) showed the shortened left tibia to have grown the same amount as the normal right tibia. The ossific centers for the lower femoral and upper tibial epiphyses are slightly smaller than the corresponding epiphyses on the right side. The lower tibial epiphysis on the left side has just made its appearance while that on the right is well developed. The ossification center for the left astragalus is now well defined but smaller than that in the right foot. Measurements of teleoroentgenograms 23 months after operation reveal that the shortened tibia is still

keeping pace with its normal fellow but that discrepancy of the total leg length has increased an additional ½ inch (1.2 centimeters) due to aplasia of the astragalus, calcaneus, and the interposed joint.

This child has a well placed foot for weight bearing purposes but functionally is disabled because of the short left leg. A shoe with a raised sole is being worn. It is possible that some procedure to equalize the length of the two legs will ultimately be necessary.

CASE 3. Female, aged 8 years, was first seen at the University of Chicago Clinics on October 18, 1932. The parents stated that she had had a short right leg since birth. This inequality had become more accentuated during the 4 or 5 years prior to admission. She had been using a built-up brace to permit weight bearing during the past 3 years. The right tendo achillis had been lengthened and some unknown operation performed about the right tibial tuberosity several years prior to being seen here.

Examination showed a normal girl of 8 years, except for the right leg and the deformed right foot. The right femur was 2 inches (5 centimeters) shorter than the left. The right tibia was 4 inches (10 centimeters) shorter than the left tibia. The fibula could not be palpated. A 15 degree anterior angulation of the tibia was present with apex at the junction of middle and lower thirds. There was 30 degrees of motion at the ankle. The foot was narrow and in slight equinovalgus. Three well defined digits were present. The girl appeared as in Figure 12. Roentgenograms (Figs. 13 and 14) show considerable anterior bowing of the shortened right tibia. The lower tibial epiphysis is smaller posteriorly and laterally than elsewhere. Posterolaterally in the lower third of the leg there is an osseous island which appears to be a remnant of the fibula. The os calcis and other tarsal bones are fused. A small apophysis is present. Three normal appearing metatarsals and their corresponding digits are present.

Because of the marked shortening and grotesque appearance of the limb, amputation was considered but was deferred for almost 2 years in order to allow further possible longitudinal growth to take place and because when first seen the patient was not overconscious of her deformity. However, comparative measurements made in June, 1934, showed the right leg to be 12 centimeters shorter than the left, a further loss of 2 centimeters, although the patient had been bearing weight during this time. A lower leg amputation was performed on June 24, 1934, by Dr. E. L. Compere. Convalescence was uneventful, the patient being fitted with an artificial limb a few months later. When last seen the patient's gait and appearance in street clothes were normal.

Dissection of the specimen obtained from amputation was carried out. The appearance of this foot after removing skin and fascia is shown in Figure 15. The fibular remnant, *A*, seen in the roentgenogram of Figure 13, was found to be encased in cartilage, which, at this age, is a maintenance of fetal conditions. An almost normal interosseous membrane was present at this level. A fibrous band, *C*, extended to the lateroposterior surface of the fused astragalocalcaneus. The inferior portion of the muscle substance of the peroneus brevis, *PB*, originated from the external surface of the osteocartilaginous fibular remnant. The peroneus longus, *PL*, was seen in its normal position external to the peroneus brevis tendon. The insertion of the first mentioned of these tendons was into the dorsal surface of the most lateral (fifth) metatarsal, while the latter inserted normally into the base of the first metatarsal and neighboring first cuneiform. The ankle joint, *AJ*, was composed entirely of the articulation of the tibia with the astragalocalcaneal mass. No midtarsal joints were found proximal to the proximal metatarsal articulations. The base of the most lateral metatarsal, *M*, projected posterolaterally, almost as far as the corresponding base of a normal fifth metatarsal. An abductor digiti quinti, *Ab*, was present and in normal relationship to the aforementioned bone. The tendons of the tibialis anticus, tibialis posticus, and extensor hallucis longus were identified.

DISCUSSION

So constant is the appearance of these patients and the evolution of this deformity when untreated that we believe they form as homogenous a group of cases as the common syndrome of congenital talipes equinovarus. As indicated before, the etiology of the condition remains obscure. Present knowledge points to a deep seated defect in the germ plasm which is transmitted irregularly as a markedly recessive character. Since embryological considerations demand that the deformity be well manifest by the sixth week of fetal life, the hypothesis of congenital amniotic adhesions and bands is unlikely. For a review of these theories the reader is referred to the writings of Scharff and others (16, 21, 24, 30, 34, 35, 42). Heredity plays some, as yet ill defined, rôle in the pathogenesis of these

skeletal anomalies. The data from human sources are meager and unimpressive. In most instances these defects have apparently appeared suddenly in an otherwise healthy stock as have our 3 cases. Volkmann and Debout found the condition to be present in 3 generations. Other authors (38) have stressed the frequent genealogical association of this deformity with other skeletal defects while Hesse states that heredity plays a rôle in less than 5 per cent of all instances of fibular defects. Frieben found instances in 3 generations including 3 sons in 1 family.

The hypotheses of defects in segmental development (ray defects of Gegenbaur) which have been used to explain many of the congenital deformities in the upper extremity cannot be pressed into service in the instance of this deformity since the missing tissue originates from two or more primitive segments. The reader is referred to the writings of Slingenberg, Gegenbaur, and Haim for the detailed development of this theory. Kanavel has recently urged this theory as an explanation for certain congenital hand deformities.

Once established, the syndrome has a definite evolution which can be seen in our 3 cases as well as in the cases reported in the literature, provided the deformity is not complicated by other congenital anomalies of the lower extremities. The relationship of factors that govern the appearance of the absent fibula syndrome to other anomalies of the lower extremity remains unknown. Lack of function (weight bearing) is not the only factor operative to produce atrophy and shortening in an extremity the seat of this anomaly. For example, our early case demonstrates shortening in both thigh and leg long before the age of weight bearing. The fibular defect varies considerably when all of the reported cases of this anomaly are viewed as a whole. In the majority of cases the whole bone is absent or only an osseous island is present at some point along the expected site of the fibula which is represented by a fibrous band, the peroneal ligament. The important essential defect in the pathogenesis of subsequent deformity is the lack of an external malleolus which allows lateral and posterior luxation of the foot.

Characteristic in the development of a leg with this deformity is the delay in ossification and development of the lower tibial epiphysis and certain of the tarsal bones, metatarsals, and corresponding phalanges. The appearance time of ossification in the lower tibial epiphysis may be additionally delayed by lack of function. For example, in Case 1, which had been neglected, this center did not appear in both limbs until between the ages of 4 and 5, while in Case 2 where early weight bearing was obtained this center appeared at 20 months. The centers for the astragalus and calcaneus appear in the deformed limb early but are likewise slightly delayed in ossification since in our youngest case only a center was present for the calcaneus at the age of 11 months while the center for the astragalus appeared between the ages of 11 and 20 months. In our cases there appears to be failure of development of the subastragalar joint. Early fusion of the ossific centers for the calcaneus and astragalus occurs, the exact time of which is difficult to estimate from the examination of roentgenograms alone. It appears (Fig. 11) that fusion may have begun at the age of 20 months in our Case 2, while in our case of bilateral occurrence of the deformity, fusion seems not to have been accomplished on both sides until the age of 8 years. In our dissected amputation specimen, the astragalus and calcaneus were found *en bloc*. This also was the experience of Wagstaffe who examined a postmortem specimen from a man 45 years of age and of Dieulafé and Cahuzac who have recorded the only other description of a dissected amputation specimen (patient aged 60 years) that we have been able to find in the literature. Reproductions of roentgenograms in reports of others likewise show the astragalus and calcaneus as a single bony mass. The occurrence of the other tarsal bones seems to be irregular. However, the almost constant presence of the cuboid is another fragment of evidence against this being a purely segmental anomaly.

One or two metatarsals with their corresponding phalanges are usually absent. The most common finding among the cases in the literature is that present in our Cases 2 and 3 and in the left foot of our Case 1. The pres-

ence of the cuboid and the configuration of the most lateral of these metatarsals suggests the absence of metatarsals two and three. Examination of our amputation specimen furnishes additional evidence for this conclusion since the structure of the lateral metatarsal is identical with the normal fifth metatarsal. Wagstaffe's findings were similar. This is not the only configuration of the foot that may be associated with absence of all or a part of the fibula. In the minority of the cases from the literature and in the right foot of our Case 1 there appear skin tags upon the lateral surface of the foot that contain small osseous fragments. When these fragments are present, the configuration of the other metatarsals suggests that the lateral metatarsals and corresponding phalanges are the missing members. In a few instances there are bifid phalanges and reduplicated phalanges distal to a single metatarsal and in a few instances a normal number of metatarsals and phalanges is present. This variability in development of the foot with constant deformity of the fibula constitutes further evidence against the application of the segmental hypothesis of Gegenbaur to this syndrome of bone anomalies.

In the field of experimental zoology, Bagg has shed new light on the etiology of congenital defects as having an origin in injury to the germ plasm occurring even before mating. So important are these findings that we will briefly review them in this place. This author was able to produce certain deformities of the feet in mice by light doses of x-ray. The descendants of animals so treated showed a high percentage of abnormalities of the limbs, mainly expressed in various forms of club feet, syndactylism, hypodactylism, congenital amputations, and polydactylism. He further found that selection in mating of the descendants of these animals increased the number with foot defects. Abnormalities of the limbs were found to be recessive in inheritance. Embryological studies showed that the earliest foot defect was associated with the formation of a blister-like bleb, which raised the epitheliums of the foot usually in a localized area, followed by the escape of blood into the bleb and formation of a localized blood clot. The extent of the pathological process and its anatomic location determined whether the later developing foot was to show congenital amputation, clubbing, hyperdactylism, or syndactylism. Bonnevie in an extended series of experiments has confirmed the above findings. On the other hand, she has been able to show that the bleb on the extremities originates from an excess of cerebrospinal fluid. Thus, such anomalies of the extremities may have a complex pathogenesis, although the underlying hereditary principles are the same.

TREATMENT

The orthopedic management of this compound deformity varies with the extent of the deformity and the age of the patient and whether the defect is unilateral or bilateral. Interference is directed at the equinovalgus foot deformity and at the bowing and shortening of the tibia. Although not recognized by the majority of previous authors, growth potentiality for the lower tibia on the diseased side must be considered. The importance of this last factor is illustrated by the results in our 1 early unilateral case.

Corner stated, "Patients can get on quite well without the fibula, and . . . lead long useful lives." Inspection of the reports alluded to by this author revealed that most (3 of 5) of these adult patients had many congenital anomalies, some in all four limbs, and thus do not come under the scope of this subject. Their appearance was far from normal and it is difficult to see how they could "have got on quite well." The older patients with absence of the fibula demonstrate only the advanced deformity that results from many years of neglect. In the 1 adult case of 45 years and in 2 children described by Wagstaffe, the foot on the affected side was pulled laterally upon the posterior surface of the tibia and fixed there by contractures. Scharff reported a thorough clinical study of a man 40 years of age who had carried the deformity without treatment. His photographs show an extreme equinovalgus deformity with posterior luxation of the foot. There were 10 centimeters of shortening of the lower limb measured from knee to the internal malleolus. Dieulafé's and Cahuzac's patient (aged 60) had only a 5

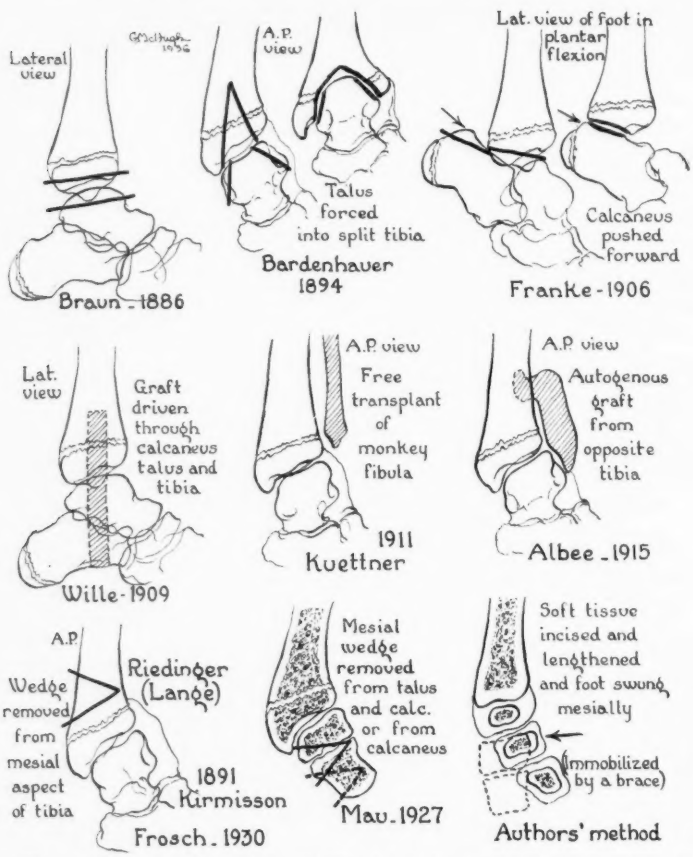

Fig. 16. Methods advocated for stabilization and correction of equinovalgus deformity resulting from congenital absence of the fibula. See text for discussion.

centimeter discrepancy in leg length, all confined to the leg but the foot was externally and laterally displaced about 40 degrees.

The methods of treatment described in the literature (Fig. 16) are chiefly cast correction of the foot deformity, osteotomy of the tibia to correct bowing, and lengthening of the tendo achillis and peroneal tendons to allow correction of the equinovalgus. The necessity of accessory capsulotomy at the ankle joint has not been frequently mentioned. Braun performed an arthrodesis of the ankle joint with the foot in equinus. Volkmann, Riedinger, and others (15, 26) advocated cuneiform supramalleolar osteotomy to correct the foot deformity. In a few cases treated in this way, non-union occurred. As a result, Mau urged that the wedge should be removed from the astragalocalcaneal region. The cosmetic results showed by this latter author commend this procedure whenever uncorrectable lateral foot displacement is encountered. Bardenhauer advocated splitting the lower end of the tibia and implanting the astragalus into it. Franke performed a fusion of the posterior surface of the calcaneus with the inferior surface of the tibia. Kuettner transplanted, as a free graft, the fibula of a monkey. This was said to have been successful in forming a lateral malleolus but a later report of results.

5 years after operation, revealed that the fibula had not grown. Indeed, reproductions of roentgenograms in this author's last paper suggest from the sharpness of outline of the transplant that it was only a functionless sequestrum in the soft tissues. Corner believed that all operative treatment for correction of the condition was futile because of associated deformities. He stated that amputation was frequently necessary. Gaenslen used only a high shoe with an inner wedge for a 7 year old girl with nearly 7 centimeters of shortening. Albee (1) used bone from the opposite deformed tibia to reconstruct an external malleolus. This graft extended laterally and inferiorly from the lower tibial metaphysis.

In many of the above reports, the possible end-results of damage to the lower tibial epiphysis by extensive operative procedure have been completely ignored and therefore must be condemned as physiologically unsound. In the recent work of Phemister it is again emphasized that the operative interference, including the placing of a bone graft across an epiphyseal line, usually results in cancellation of longitudinal growth at that epiphysis. Thus, the methods of Bardenhauer and Wille could not be applied until adolescence. It is certain that arthrodesis as advocated by Braun and Franke could not be carried out much before the age of 8 or 10 years without danger of arrestment of longitudinal growth from the lower tibial epiphysis since the osseous development of that epiphysis is greatly delayed. Upon theoretical grounds, the operation advocated by Albee is unsound for young children, since the newly constructed lateral malleolus will ascend with longitudinal growth. Absorptive changes, moreover, will take place on the free surfaces of the graft. If the graft fuses across the epiphyseal line, progressive ankle deformity will occur. Turner has recently demonstrated actual specimens showing such deformities at the ankle joint in adults treated in this way in childhood. We have found in the literature only 2 reports of the late results obtained by the procedures previously mentioned and thus cannot demonstrate all the deformities that would certainly follow. Haas, however, reported a satisfactory end-result of a well alined limb 20 years after having carried out an operation similar to that described by Albee. Waterman observed a patient at 12 years of age upon whom the Bardenhauer procedure had been performed at the age of 1. While condemning the procedure as unquestionably having interfered with longitudinal growth at the lower end of the tibia, the observed discrepancy in leg length at the time of his report was only 9 centimeters. In a report 7 years after an operation implanting a graft from the lower ulnar shaft to the carpus for congenital absence of the radius, Albee (2) stated that function was good. Roentgenograms showed increased radial deviation and detachment of graft from the carpus, presumably by the impetus of longitudinal growth.

We would restrict interference in this deformity to those methods that are physiologically sound. We recommend in children that the foot be alined with the tibia for weight bearing. This should be done as early as the child can be seen. If cast correction fails, as it did in the 2 cases of our series where this was first carried out, operative replacement of the foot is indicated. Cognizance must be taken that the calcaneus is frequently as high as the posterior surface of the tibia as well as being displaced laterally. Lengthening of the posterior and lateral structures must be done, usually with capsulotomy. Special care must be taken not to damage the lower tibial epiphysis or the astragalus since at an early age these are largely cartilaginous. Cast immobilization in a slightly overcorrected position (Case 2) is carried out for at least 6 weeks. Weight bearing may be started as soon as a week after the operation. After removal of the cast, a short leg brace to maintain correction is frequently necessary. Constant and early weight bearing is advised to act as a stimulus to longitudinal growth. Our Cases 1 and 3, as well as many of the cases already reported in the literature demonstrate the neglect of early weight bearing. It cannot be stated at this time how much of the shortening seen in older cases is due solely to such neglect. We do not believe that arthrodesis of the lower tibial epiphysis with the astragalus is always necessary to establish

lateral stability of the ankle. If lateral instability is a prominent feature in the later management of these cases either bracing or arthrodesis of the tibio-astragalar joint can be done. If the latter is preferred, the operation must be delayed until an adequately large ossification center is developed so that the operation can be executed without danger of damage to the epiphyseal cartilage plate. In older cases (10 years or more), if sufficient anterior bow of the tibia remains, this can be corrected by osteotomy with minimal excision of bone, because of the ever present danger of non-union. Most of the cases presenting this deformity below this age will straighten spontaneously if early weight bearing is carried out.

Equalization in leg length in older patients (beyond the age of 10 years) is a problem only if the deformity is unilateral and if the shortening is not too great. Case 1 of our series has a normal walking gait since the condition is present in both limbs (Fig. 3). The means of equalization of leg length will vary with individual preferences. A high shoe, or orthopedic prosthesis can be used. Operative arrestment of longitudinal growth of the sound extremity at a suitable age by epiphyseo-diaphyseal fusion (36) can be considered but will be feasible only in persons of normally advanced height.

In many cases, shortening of the sound limb by this method or by actual excision of diaphyseal bone is not suitable since such procedures would result in too much loss of total height. Thus, such cases can always be best treated by low leg amputation in the preadolescent period and the fitting of a suitable prosthesis (Case 3). Periodic observations of both tibias by the roentgen-ray after the production of phosphorus lines (Case 2) will furnish information on longitudinal growth that will be a guide to subsequent treatment. Leg lengthening can be considered by one skilled in this procedure in adolescents or young adults of short stature where the discrepancy is not too great.

SUMMARY AND CONCLUSIONS

1. Three representative cases illustrative of various problems in the treatment of the syndrome associated with congenital absence of the fibula are reported.

2. The embryological basis and the natural evolution of this compound deformity in the growing child are described. The defect is probably one of the germ plasm affecting the limb bud. Evidence is given that associated defects in the foot are not always constant. Roentgenographic studies and dissection of one amputation specimen shows that the defect is not entirely one of the outer portion of the limb bud.

3. Many of the methods of treatment advocated in the literature are physiologically unsound. We have pointed out the procedures that are applicable in the treatment of this condition.

ADDENDUM: While this article was in press, the authors, through the courtesy of Dr. Gerald M. Greenspahn, have seen an additional bilateral case in the wards of the Cook County Children's Hospital. The feet were similar in appearance to those in our Case 1 except that four well formed metatarsals were present in one foot, with the usual three in the other.

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PENTOTHAL SODIUM FOR INTRAVENOUS ANESTHESIA

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WHEN it has been decided that surgical intervention is required, the choice of the anesthetic agent and the method of its administration suited to the particular case becomes important from the standpoint of comfort and safety of the patient. A proper choice of anesthetic will facilitate the surgical procedure. Special methods of anesthesia have received more attention in recent years as new anesthetic agents and apparatus for their administration have become available; in addition, requests for the employment of such special methods have become more frequent.

The way in which enthusiasm for intravenous anesthesia is growing is remarkable. Requests for anesthesia by this method are increasing in frequency both from patients who have experienced this type of narcosis and from surgeons. Pentothal sodium (sodium ethyl, 1-methyl butyl thiobarbituric acid) (3) is one of the newer derivatives of barbituric acid which is suitable for this type of anesthesia. It differs from pentobarbital sodium (nembutal) in that one atom of oxygen has been replaced by an atom of sulphur on the urea side of the molecule (Fig. 1). Pentothal sodium is available in crystalline form in ampuls containing 1 gram of the drug. A 5 per cent aqueous solution is prepared prior to administration, the distilled water being supplied in companion ampuls. A large caudal needle is used for mixing and aspirating the solution into a 20 cubic centimeter syringe. For injection, an 18 or 20 gauge needle is used. The prepared solution of pentothal sodium should be pale greenish-yellow and it should be clear. It has a slight odor of sulphur.

Satisfactory sedation may be obtained by the preliminary administration of ⅙ grain (0.01 gram) morphine sulphate and 1½ grains (0.097 gram) of pentobarbital sodium. For minor surgical procedures preliminary medication may be omitted. If intravenous anesthesia is likely to be supplemented by inhalation anesthesia, it is advisable to administer 1/150 grain (0.0004 gram) of atropine sulphate half an hour prior to operation.

While the patient is being prepared and draped for operation in the usual manner, the anesthetist may determine which superficial vein he will use for the injection. The cubital veins are usually the most prominent and accessible. The arm is placed on a well padded board and is secured in position by a turn of adhesive tape. If the cubital veins are not easily accessible, it may be feasible to use a vein on the back of the hand. The skin is sterilized with alcohol, a tourniquet is applied, the patient is asked to clench his fist, and the needle is inserted. When the vein is entered, the tourniquet is loosened and the injection is begun. The patient is then asked to count slowly and distinctly. The average adult is given an initial dose not exceeding 4 cubic centimeters of a 5 per cent solution, which is injected in from 15 to 25 seconds. The patient seldom is able to count beyond 20. The operative procedure may now be started as, at this point, surgical anesthesia with a fair degree of relaxation should be attained. If the patient winces a little or mutters, 0.5 to 1 cubic centimeter more of the drug should be injected. The needle is kept in the vein throughout the operation and 0.5 to 1 cubic centimeter is injected from time to time as indicated by signs of lightening anesthesia. It is helpful to inject a very small amount at intervals in order to clear the needle, otherwise the needle may clog and it will be necessary to re-insert it. Respiration is the best single guide for evaluating the depth of anesthesia. There may be slight movement of the feet or phonation may indicate that more of the drug is needed.

As depression of respiration is one of the main effects produced by the drug, it is essential that a free airway (2) be constantly maintained, and to this end it is necessary to have

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the services of an assistant during administration. It is the assistant's duty to elevate the relaxed jaw or to insert an artificial airway should this be necessary to facilitate respiration. The assistant should carefully observe respiration and make certain that there is an actual exchange of air. He should ascertain the rate of the pulse, and blood pressure readings should be obtained frequently. He should be prepared to administer oxygen if respiration becomes inefficient or if any degree of cyanosis develops. This method of administering the anesthetic as outlined overcomes to a certain degree the objection that an injected dose of the anesthetic agent is not recoverable, for the agent is broken down rapidly in the body and, by injecting small fractional doses, administration is comparable to that of ether by the open drop method. Dosage is not calculated on the basis of body weight, the amount of anesthetic injected being governed by the physiologic response and the usual signs of anesthesia. The initial injection should be reduced for debilitated or aged individuals, and in such cases administration should be undertaken slowly and cautiously, respiration being carefully observed.

Intravenous anesthesia is contra-indicated in cases in which there is respiratory embarrassment due to cardiac decompensation, bronchiectasis, or advanced pulmonary tuberculosis. Dyspnea from any cause should contra-indicate the administration of pentothal sodium. A general anesthetic agent of any kind should be avoided if food has been ingested within 3 hours of the time of operation; however, if intravenous anesthesia is desired and it is not possible first to wash out the stomach, the following suggestion may prove helpful: Put the table in a slight Trendelenburg position, have a suction tip at hand, have a gas machine equipped with carbon dioxide and oxygen available, and finally, keep the patient in fairly deep anesthesia during the surgical procedure. With intravenous anesthesia the reflexes of the pharynx and larynx are obtunded to a greater degree than when nitrous oxide and oxygen is employed. If general anesthesia is necessary when the patient's stomach is not empty, it is preferable to administer nitrous oxide and oxygen, or cyclopropane and oxygen, for, if emesis should ensue, a breath or two of pure oxygen will restore the laryngeal reflexes and the patient will be able to protect himself against aspiration of foreign material.

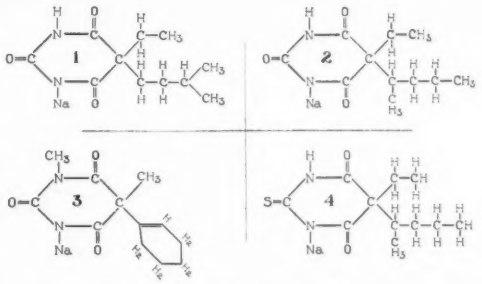

Fig. 1. Progress in the production of shorter acting barbiturates; (1) sodium amytal, (2) nembutal (pentobarbital sodium), (3) evipal soluble, (4) pentothal sodium.

Unpleasant symptoms during induction of anesthesia with pentothal sodium are seldom experienced. Patients, when questioned afterward, tell only of a sleepy sensation, which was not unpleasant to them, and they remember nothing further until they recover from the anesthesia. Struggling or restlessness is seldom exhibited, and only very occasionally is a slight tremor noted. During anesthesia the patient is apparently in a deep, quiet sleep with regular shallow breathing; on recovery, nausea or restlessness is seldom encountered. Frequently the patient will begin counting again where he left off during induction, but he soon becomes oriented and remembers nothing of what took place in the interim. There are, however, some features of the recovery period that resemble mild alcoholic intoxication, and this is usually in proportion to the amount of the drug used during anesthesia. These signs and symptoms may persist in a mild degree for some little time after recovery, and it is best not to allow the ambulatory patient to leave the hospital unaccompanied or to drive his own car.

Pentothal sodium produces satisfactory surgical anesthesia for many procedures, for example, drainage of abscesses, biopsy, cystoscopy (6) and ureteral catheterization, dilatation and curettage, operations on the eye

TABLE I.—INTRAVENOUS ANESTHESIA WITH PENTOTHAL SODIUM* (JUNE 18, 1934, TO JUNE 1, 1936)

		1936	1935	1934
1	Operations on brain, spinal cord, and peripheral nerves	59	76	3
2	Operations on eye	30	52	20
3	Operations on head and neck (other than the above)	117	276	9
4	Dental extractions	15	32	2
5	Transurethral and cystoscopic operations and manipulations	237	458	25
6	Orthopedic operations	26	44	1
7	Operations on thorax, thoracic wall, breast, and axilla	77	158	1
8	Digestive system operations	2	9	..
9	Operations on the large bowel	40	40	7
10	Intra-abdominal operations	2	8	..
11	Operations on abdominal wall and for hernia	23	23	..
12	Gynecological operations	170	147	4
13	Operations on anus	21	10	1
14	Total	819	1333	73

*Distribution of cases in which pentothal sodium was used either to induce anesthesia or maintain it, according to the type of surgery that was done.

(including adjustment of muscles or enucleation), dental extraction, removal of packs, and many minor procedures. However, there is usually not sufficient relaxation with this agent to facilitate intra-abdominal procedures, although pentothal sodium may be used to induce general anesthesia.

Intravenous anesthesia is useful when a nodule is to be removed from a breast, the type of surgical procedure then being determined by the report of the surgical pathologist at the time of operation. The patient might be informed beforehand that, if the condition proved to be more serious than expected, a more radical procedure would be carried out. The nodule can easily be removed under intravenous anesthesia and, if the condition should prove to be malignant, inhalation anesthesia would carry the patient satisfactorily for the longer radical procedure; in this way the patient would not know of the more serious diagnosis during operation, as would be the case if local anesthesia were employed. The intravenous agent provides for an easy induction and, when supplemented by inhalation anesthesia, the transition is smooth and quiet. We believe that this method is superior to local anesthesia, for the discomfort of the infiltrating needle is avoided as well as the possibility of producing metastasis through mechanical interference if the condition is malignant. If the nodule proves to be benign, intravenous anesthesia is adequate for the entire procedure even though simple amputation of the breast is indicated.

With pentothal sodium easily and immediately available in an operating room, it may be used in the control of convulsive states occurring during anesthesia produced by other agents. Pentothal sodium has been successfully used, for example, in the control of convulsions produced when a large amount (8 cubic centimeters of a 10 per cent solution) of cocaine was injected subcutaneously. For convulsive states encountered occasionally during the administration of agents capable of producing general anesthesia, the initial untoward reaction may be controlled by the intravenous administration of either evipal soluble or pentothal sodium. Because elimination of the agent responsible for the convulsions may be a prolonged process, it is well to change when possible to the use of longer acting barbiturates, such as nembutal or sodium amytal. This is true, also, in the case of convulsions encountered in eclampsia (7), tetanus (4), or poisoning from strychnine (5).

Pentothal sodium may also be used as a prognostic agent (1). Following its intravenous administration, the temperature of the extremities rises to the maximal point. If in a case of Raynaud's disease the temperature of the fingers fails to reach 35 degrees C., one may conclude that some peripheral vascular condition exists and that section of the cervicothoracic sympathetic nerves will not completely relieve the condition. In cases of essential hypertension, the lowest point to which the blood pressure falls during injection of a dose of the drug sufficient to produce a maximal rise in the temperature of the extremities fairly well indicates the point to which the blood pressure will fall following neurosurgical intervention. The operation performed in cases in which patients respond satisfactorily to this test is two stage bilateral

resection of the splanchnic nerves, first and second lumbar ganglions and connecting rami, and partial resection through modified kidney incisions of the celiac ganglions and suprarenal glands. For this test, the average adult dose is 15 cubic centimeters of a 5 per cent solution of pentothal sodium injected in approximately 15 minutes. A thermocouple is attached to each of two or three toes of each foot. Injection is continued intermittently until the temperatures reach a maximum. The blood pressure and temperature of the skin are determined every 2 minutes during anesthesia. Usually the maximal skin temperature is attained within 15 minutes. The "preoperative prediction values" are the lowest systolic and the lowest diastolic pressures obtained during the test.

From June 18, 1934, to July 20, 1936, pentothal sodium was employed for the production of anesthesia 2,700 times. Distribution of the cases for these years according to the the type of operation performed may be noted in Table I. Experience gained permits the following conclusions: Pentothal sodium is the most effective short acting barbiturate that has come to our attention. The drug is so rapidly destroyed within the body that intermittent administration throughout the operation permits control of the depth of anesthesia comparable to that obtained when ether is administered by the semi-open drop method. Recovery is rapid and is not associated with nausea or undue restlessness. The drug is less well tolerated by children than by adults. It may be employed for operations of short duration when thorough relaxation is not essential. Pentothal sodium is a potent drug and should be administered by an experienced anesthetist capable of dealing with problems that may develop during general anesthesia.

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CERTAIN CHEMICAL FACTORS IN EXPERIMENTAL HIGH INTESTINAL OBSTRUCTION

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HIGH intestinal obstruction in dogs is associated with a short duration of life. Haden and Orr (5) found that with obstruction to the upper jejunum the average duration of life was 6.8 days. Wangensteen reported a survival period of from 3 to 4 days and Dragstedt and Moorhead noted that animals with an obstruction just below the pancreatic duct lived only 96 hours. It is generally accepted that the symptoms in intestinal obstruction are due to some toxic agent which develops soon after obstruction begins. Tileston and Comfort, and Cooke, Rodenbaugh, and Whipple noted that there is a gradual increase in the non-protein nitrogen and urea nitrogen. Draper adds a finding of a high uric acid value in one dog just previous to death. Haden and Orr (5) have also shown that in high intestinal obstruction there is a progressive alkalosis and a remarkable fall in chlorides due possibly to the utilization of the chlorine ion in the course of the intoxication. MacCallum, Lintz, Vermilye, Legget, and Boas also demonstrated a similar drop in the chlorides after section of the pylorus in dogs and McCann found that following operations on the stomach which exclude acid from the duodenum, tetany develops which simulates parathyroid tetany. Hastings, Murray, and Murray have also made studies on dogs after ligation of the pylorus. They found a progressive alkalosis, a slightly elevated calcium content, and a decrease of sodium and chlorine electrolytes. It is suggested that these changes in the blood chemistry may account for some of the symptoms in the animals with high intestinal obstruction.

A new aspect to this problem has been introduced by Johnstone, Clasen, and Orr, who have shown that animals survive for as long as 23.5 days with a high jejunal obstruction if the portion of the gut containing the major pancreatic duct is transplanted to an area below the obstruction. This result closely parallels the work of Eisberg and Draper and of Jenkins in which sections of liver, duodenum and pancreas are drained into the jejunum below the site of the obstruction. The work of Haden and Orr (6) showed, moreover, that if the jejunum is divided and its proximal end drained to the outside, dogs die as quickly as if the jejunum had been obstructed. It would appear then that the secretions of the various organs into, and from, the small bowel are essential to life.

This problem has intrigued us from two different aspects: (1) the possible nature of the toxemia, and (2) the relation of the absorption mechanism in the intestine itself.

The first group of experiments concerns itself with tying off various portions of the duodenum in dogs above and below the pancreatic ducts as in Figure 1.

Several normal healthy dogs were chosen which had been kept on a high carbohydrate, low fat diet with protein in moderate amounts for 2 weeks. Under nembutal anesthesia the abdomen of a fasting animal was opened and an area of the duodenum chosen for occlusion. Into this area dextrose and sodium chloride solutions were injected. Careful attention was observed so that the blood and nerve supply were not interfered with. As the results were consistent they are represented in the accompanying tables for the entire group.

It will be noted that, after either dextrose or saline is placed in area I, the rates and the amounts of absorption are much less than if the solutions are injected in either areas II or III. Furthermore, if dextrose is injected in area I only a negligible amount of it appears to be absorbed. This would lead one to believe that in order for satisfactory absorption to take place the injected fluid must be mixed with the secretions going through the pan-

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TABLE I.—PORTAL VEIN DEXTROSE VALUES (MGM. PER CENT) AFTER INJECTION OF 20 C.CM. OF 5 PER CENT DEXTROSE INTO THE AREAS OUTLINED IN FIGURE I

	Pre-injection value	5 min.	10 min.	20 min.	40 min.
Area I	102	104	100	118	114
Area II	104	168	240	248	200
Area III	98	162	170	151	152

TABLE II.—PORTAL VEIN CHLORIDE VALUES (MGM. PER CENT) AFTER THE INJECTION OF 40 C.CM. OF .9 PER CENT SODIUM CHLORIDE

	Pre-injection value	5 min.	10 min.	20 min.	40 min.	60 min.
Area I	465	460	500	510	504	491
Area II	500	520	584	590	620	598
Area III	480	515	570	540	538	540

TABLE III.—RISE IN SERUM VALUES FOLLOWING OBSTRUCTION AT (D)

Dog No.	Day after operation	Blood values (mgm. per cent)			
		Potassium	Chlorides	NPN	CO_2 Content (in c.cm. per cent)
I	1	17	470	26	40
	2	28	310	60	44
(d)	3	36	300	87	48
	4	56	280	100	51
	Death				
II	1	21	500	22	36
	2	44	320	70	42
(d)	3	71	260	94	54
	Death				
III	1	16.1	520	25.1	42
	2	26	460	62	44
(d)	3	42	410	71	48
	4	64	380	84.2	51
	Death end of sixth day				

creatic duct containing both pancreatic juice and bile or liver ferments. It appears, moreover, that if area III is obstructed from area II the rate of absorption is decreased. If, however, area II and area III are not separated by an obstructing band the rates of absorption not represented in the tables will be the same as in area II. Intestinal obstruction, therefore, in the small bowel must depend to a

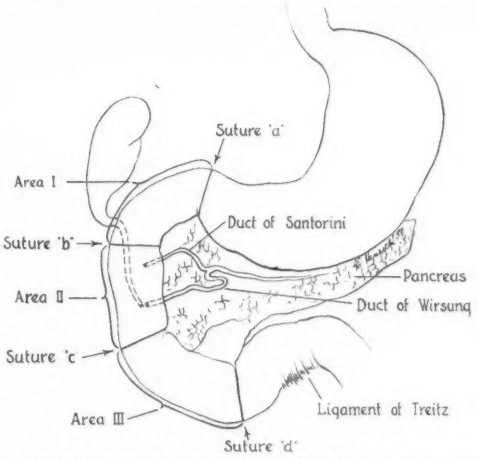

Fig 1. Schematic drawing indicating points of suture in experiments.

large extent on the fluids produced by the pancreas and liver. This may explain in part the reasons why high intestinal obstruction is so disastrous to animal life. On the other hand, this would by no means explain the rapid loss of chlorides from the animal body, such as is seen in high intestinal obstruction, because by simple starvation the survival period is much longer. Obstruction just above the ligament of Treitz, equivalent to area III, was carried out in 3 dogs. The dogs failed to live longer than 4 days (Table III). We were struck by the fact that not only was there a remarkable drop in the blood chlorides but that there was an increase in the blood potassium. The blood calcium values (not given in the table) varied but little. The increase in the blood potassium is of about the same magnitude as is found following adrenalectomy. Other dogs in which this same procedure was carried out were given potassium chloride intravenously, and death was precipitated within an hour after the injection of 10 cubic centimeters of 1 per cent potassium chloride, an amount which is tolerated by normal dogs. In short, we were led to believe that this increase in the plasma potassium content might account to a considerable extent for the moribund condition present in the animals and possibly for the death of these animals. The non-protein nitrogen and the progressive

alkalosis are referred to merely as confirmatory findings. Hastings and Compere in 1931 called attention to the fact that, after adrenalectomy, a rise in potassium may account for the death of the animal. The findings that we have presented might in some way be of a similar nature.

CONCLUSIONS

High intestinal obstruction is associated with the factor of delayed absorption of material from the duodenum. The liver and pancreatic juices play a rôle in the absorption of dextrose and saline from the intestine. There is a definite increase in the blood potassium following high intestinal obstruction which may in some measure play a rôle as one of the contributory factors in the cause of death in these animals.

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PITRESSIN (BETA-HYPOPHAMINE) IN LAPAROTOMIES

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KAMM, in 1928, separated an extract of the posterior pituitary gland into two active principles, which he called pitocin and pitressin. Pitocin, the oxytocic factor, has little effect other than its power to increase contraction of uterine muscle. Pitressin, however, has several other effects which vary somewhat in animals and in man. The three most important in man are: (1) the stimulation of intestinal peristalsis, (2) the reduction of kidney excretion, and (3) the pressor influence on the cardiovascular system.

Since these three effects are bound up in the pressor fraction, it is necessary to evaluate their relative importance before using pitressin clinically.

THE EFFECT OF PITRESSIN ON THE INTESTINE

Some physiologists have shown that the effect of pituitrin and pitressin on the intestine of the dog is largely one of inhibition (21, 32, 45, 46, 49). Some have reported increased activity, this varying according to the animal, the dosage, and the experimental conditions, but occurring rather uniformly in the rabbit (13, 14, 24, 33, 34).

Dale claims that pituitrin acts directly on intestinal muscle without any relation to innervation. Pancoast and Hopkins, in careful observations on humans with a barium meal, found no very important changes in gastro-intestinal motility.

In spite of the inhibitory effect on the intestine of the dog, its power to aid in the expulsion of gas in the human is a recognized clinical fact. Bell was one of the first to report the efficacy of pituitrin in the treatment of postoperative distention. Innumerable reports have followed. H. A. Carlson, by making use of balloons in colostomized patients, showed that pituitrin stimulates the intestine of man, but that in the dog this is the exception rather than the rule. Similarly Bargen and Guthrie, by placing balloons into various parts of the bowel through colostomy openings, found that surgical pituitrin produces powerful contractions in both the small and large bowel. These begin in 3 to 5 minutes and last 45 to 90 minutes. They also tried physostigmine, peristaltin (cascara extract), and acetyl choline. These had little effect. MacDonald and Settle likewise used the balloon method in 15 colostomized patients. Pitressin, 1 to 2 units, given intravenously caused stimulation in each instance. Pitocin, 5 to 10 units, was effective in only 3 out of 11 patients.

Pitressin not only contains the intestine activating factor in posterior pituitary extracts, but in addition it seems more active in this respect than the whole extract. Melville (33) and Elmer and his associates think that the oxytocic factor is antagonistic to this action of the pressor factor. The oxytocic factor in the surgical use of pituitary extracts is not necessary, but from a theoretical as well as a practical point of view the use of pitressin in abdominal distention is preferable to that of the whole extract.

Because of this controversy regarding the pitressin effect on peristalsis, we devised a simple experiment to determine its effect upon the human colon. Several hours after the bowel has been cleared out by an enema, a large stomach tube is inserted into the rectum, and the colon is inflated with air to the point of mild discomfort. Usually 500 to 1000 cubic centimeters of air suffice. The tube is then attached by a Y connection to both a water manometer, from which readings can be taken directly, and a tambour which records changes in intracolonic pressure on a smoked drum.

Figure 1 is the record of such an experiment. The small waves are respiratory movements, the large ones bowel contractions. Readings at the bottom indicate the pressure

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in millimeters of water as recorded by a water manometer in the circuit. Most readings represent the peak of a contraction directly above them. Two minutes after the intramuscular injection of 20 units of pitressin there appeared a strong contraction raising the pressure to 180 millimeters of water. The bowel was definitely stimulated. A second injection, 42 minutes later, produced such a severe contraction that the individual squirmed with pain and air escaped about the rectal tube. These cramps continued for 25 minutes; the bowel was then emptied of air and the cramps promptly ceased. The effect has been invariably the same in other instances. Sometimes the 20 unit dose causes unbearable distress and the pressure must be relieved. After 20 units, the subject usually has epigastric distress and frequently has nausea. In every case there is a definite blanching of the skin, which is accompanied by no other untoward symptoms. Not infrequently the subject has a large soft or liquid bowel movement. In most persons 10 units of pitressin is an ample dose, and in normal individuals this amount generally is effective without causing undue distress.

Conclusion. In man, pitressin in 20 unit doses produces powerful contractions of the distended colon with expulsion of its content. Doses of 10 units are preferable in normal individuals, because they are only a little less effective and cause much less distress.

THE EFFECT OF PITRESSIN ON THE VASCULAR SYSTEM

Many diverse effects on the blood pressure in animals have been reported; these variations have been due in a large part to the differences in dosage and in the experimental conditions. With small doses, pitressin produces a lasting elevation of blood pressure; with large doses there is a secondary fall due to cardiac weakness and dilatation as a result of coronary constriction (47).

Ward found that after the injection of vasopressin (pitressin) in a series of 48 cases there was an average rise in the systolic and diastolic pressures of only a few millimeters of mercury. The pulse rate was slightly diminished. The effect occurred in 5 minutes and was practically gone in 15 minutes. With double this dosage the systolic and diastolic pressures rise approximately 10 millimeters and the pulse rate falls about 10 beats per minute.

MacGregor gave 1 or more ampuls of pituitrin to 30 patients during labor and found no uniform tendency to elevate the blood pressure. Nine patients showed a rise of 10 millimeters or more in 5 or 10 minutes, but this was not sustained.

Moffat gave 1 cubic centimeter of obstetrical pituitrin to 62 individuals and found no constant rise in the blood pressure. In fact, the trend was downward rather than upward. In 3 hypertension cases there was a fall in blood pressure.

Dieckmann, in a series of 21 pre-eclamptic patients, obtained a rather profound rise which averaged 49 millimeters of mercury.

We have found a similar exaggerated effect in thyrotoxicosis and for this reason *believe it to be contra-indicated in pre-eclampsia and in thyrotoxicosis.* In our series of 20 patients with blood pressure readings taken 5 to 10 minutes after injection of 20 units intramuscularly there was an average rise in systolic blood pressure of 6 per cent, and in diastolic of 5.5 per cent. In only 2 instances did the blood pressure drop and in no instance was the rise over 15 millimeters of mercury. The changes with 10 units are similar and of only slightly less magnitude. The rise occurs a few minutes after injection, reaches a maximum in 5 minutes, and is gone in 20 minutes. In an eclamptic toxemia, after cesarean section, the systolic blood pressure rose from 156 to 168, the diastolic from 133 to 141. In 2 cases of hypertension there was little change.

Although pitressin has a tendency to diminish the pulse rate in normal individuals (16, 22) this was not a finding in our postoperative cases. If anything, the pulse rate became slightly increased. One, therefore, need not be alarmed by its possible pressor effect. It is not large enough to produce postoperative hemorrhage or to cause injury in hypertension and, by the same token, it is not great enough to benefit shock.

Pitressin given intravenously in relatively large doses to animals causes coronary constriction with reduced coronary blood flow,

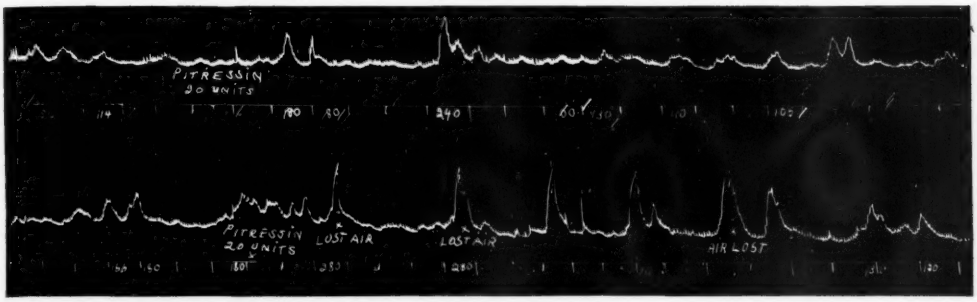

Fig. 1. A tracing of the intracolonic pressure of a normal individual's colon inflated with 1000 cubic centimeters of air. The small excursions are respiratory waves, the larger ones are peristaltic waves. The time is marked in minutes. The figures below the base line represent the height of contractions above them in millimeters of water. The first injection of pitressin is followed in 2 minutes by a sharp peristaltic wave. The second injection of pitressin which is given 42 minutes after the first one, again brings on, in about 2 minutes, violent contractions which are accompanied by sharp subjective distress.

dilatation of the heart, a fall in blood pressure, and ecchymoses under the endocardium. The course of events in the dog after an intravenous injection of a large dose is as follows: There is an immediate rise in blood pressure due to vasoconstriction, then coronary vessel constriction which results in a weakened heart action, with dilatation of the heart, and a sharp drop in blood pressure. The heart recovers in a few minutes and the blood pressure then again rises above the normal (18, 19, 25).

With intramuscular injection in man there is a marked peripheral vasoconstriction with blanching of the skin. The pallor after 20 units has been injected is intense, but the patient does not feel nearly so ill as his appearance would indicate. Resnik and Geiling, as well as Milles, have shown that following intravenous injection in the dog, electrocardiographic changes, similar to those of anoxemia, occur as a result of coronary constriction. In addition, Nedzel and Petersen, by intravenous injection of 10 units in 5 kilogram dogs, have been able to produce hemorrhages under the endocardium which later frequently become the seat of ulcerative endocarditis.

When one contemplates these rather deadly cardiac effects, he feels a bit concerned. However, all of these phenomena are produced only by intravenous injection in doses 10 to 20 times the therapeutic dose in man. E. Vogt, using it intravenously in continuous venoclysis, noticed immediate vasomotor reactions, i.e., blanching of the skin, a rise in blood pressure, pain in the abdomen, and difficulty in breathing. He seems to attach little importance to them. Potter (42), in his series of 1,200 cases in which 20 units were used routinely, found that blanching of the face and extremities without changes in the blood pressure or pulse rate was of frequent occurrence. Occasionally a patient vomited following every injection. This has also been our experience. In addition, he encountered 10 cases of rather severe shock, which he thought was due to the drug entering the blood stream directly. This is a possibility and if due to cardiac weakness could be promptly controlled by the use of ephedrine or epinephrine, both of which abolish the diminution of cardiac output due to pitressin.

We have had 2 experiences that might be attributed to the cardiac effect of the drug. First, an elderly man with diverticulitis went into a shock-like condition soon after a second injection of 20 units in 2 hours, but he quickly recovered. Second, a man, aged 61 years, with a ruptured bladder of 36 hours' duration, was given 10 units about 5 times daily for 8 days, that is, 40 ampuls in all. He was making an excellent recovery from a severe peritonitis but died on the thirteenth day of heart trouble. At autopsy the abdomen appeared perfectly clean. Death was due to coronary sclerosis and myomalacia of the ventricle. It is probable that the pitressin did not cause the pathological condition, but it certainly was potentially dangerous.

TABLE I.—AVERAGE FLUID AND CHLORIDE INTAKE AND OUTPUT FOR FIRST 18 HOURS AFTER OPERATION IN 16 CONTROLS AND 16 ROUTINE PITRESSIN CASES

	Fluid intake	Chloride intake	Urinary output	Chloride output	Chloride concentration per cent
Controls	2274	9.5	402	2.1	0.6
Pitressin series	2300	9.34	336	2.0	0.8

Conclusion. The blood pressure generally rises after an injection of pitressin, but the rise is not large or long sustained, while the deleterious effects of pitressin on the heart or blood pressure do not occur with ordinary therapeutic doses, one should hesitate to use large or repeated doses in an old man who shows evidence of coronary sclerosis. These effects are very marked on intravenous injection and for this reason this route of administration is not advisable.

INFLUENCE ON URINARY OUTPUT

The vasopressor principle in posterior pituitary extracts contains an antidiuretic factor. Pitressin has been reported to have both a diuretic and an antidiuretic effect. Geiling thinks that its antidiuretic effect is in all likelihood its normal action, and that diuresis is the result of variations in the experimental conditions. MacDonald from experiments on man and animals concludes that the diuretic action, if it occurs, is always associated with a rise in blood pressure and is always followed by an antidiuretic effect.

In man the effect is always antidiuretic, never diuretic. If a normal individual is given a liter of water, and then an injection of even less than the therapeutic dose of pitressin, the expected diuresis is delayed and diminished for a number of hours (6, 15, 50). This action is probably due to an increased absorption of water from the loops of Henle (7, 18). At least it is a pure renal effect with no alteration in water absorption and is followed by a compensatory diuresis (31). The chloride excretion may be increased (31, 44, 51). Dieckmann and Michel found in normal pregnant women a decrease in the volume of urine, and an increase in chloride concentration; in pre-eclamptic women the reduction in urinary volume was very marked.

TABLE II.—URINARY OUTPUT IN SECOND SERIES, 38 PATIENTS

	First day		Second day	
	Fluid intake	Urinary output	Fluid intake	Urinary output
Controls	2093	453	2002	703
Pitressin series	2115	477	2460	612

Since a reduction in urinary output is harmful in a patient who has been operated upon it is necessary to investigate the matter. Table I is self-explanatory. Sixteen controls with similar operations are compared with 16 cases receiving pitressin routinely before operation and every 4 hours thereafter. The urinary output for the first 18 hours is diminished, the chloride output is the same, the chloride concentration is increased. The data in this series are reasonably accurate and correspond closely to experimental findings.

In Table II the daily urinary output of a second series of 38 patients in whom pitressin had been used routinely every 4 hours is compared with a similar series of controls. For the first day the figures are approximately the same. On the second day there is a diminution of urinary output in the pitressin series. These figures may be a bit misleading in view of the fact that the patients were not as closely supervised, and there were a number with constant gastric siphonage, in whom the fluid output through the stomach tube was not calculated. The urinary output of patients who had from 3, 4, 5, to 9 ampuls a day was also compared. The output was about the same regardless of the number of ampuls.

Conclusion. The tendency to a decreased urinary output is not sufficient to be of clinical importance, except possibly in patients with an already damaged urinary system in whom it should be used with caution. It is very unlikely that 1, 2, or 3 injections could have under any circumstance any serious sustained effect on urinary output.

PITRESSIN IN POSTOPERATIVE ATONY

Pitressin and pituitrin have been used in the treatment and control of postoperative

distention in 3 ways: (1) in the treatment of postoperative atony, (2) in the treatment of the paralytic ileus of peritonitis, and (3) as a routine measure for the prevention of distention. We have carried out a clinical investigation to study the problem from these 3 angles. In addition to our own observations, a full time technician was assigned for 6 months to make observations and measurements, and to gather data under our direction. The cases investigated were, for the most part, those in which gynecological operations had been performed, since these operations afforded us fairly well standardized operative procedures for comparison.

Following any laparotomy the gut becomes more or less paretic and is distended by gas. The paresis is largely the result of trauma and is more or less directly proportional to the severity and the duration of the trauma, not only to the gut itself but to the abdominal wall and the retroperitoneal structures. Large quantities of blood left in the abdominal cavity increase the atony, but not as certainly as a bit of toxic or infected material. The distention usually lasts 48 hours and efforts to move the bowel within that time are futile. Of necessity, in addition to a paralysis there must be gas or there will be no distention. The gas has 3 sources; first, the bacterial and enzymic fermentation of the contents of the gut; second, the diffusion of gas, chiefly nitrogen from the blood stream into the bowel lumen; and, third, the swallowing of air. Of these 3 the last source accounts for most of the gas. Hibbard and Wangensteen have shown that if intestinal obstruction is produced in a dog which has an esophageal fistula distention is slight; they have calculated that 68 per cent of the gas in the distended bowel is swallowed air. Thus it is obvious that if one were to prevent postoperative distention he could do it most perfectly, first, by reducing to a minimum the amount of irritation and trauma in the abdominal cavity and its vicinity; second, by eliminating from the gut tract all material that would produce gas; and, third, by preventing the swallowing of air. To accomplish the first of these is the personal affair of each surgeon in each operation. A relatively empty gut can be obtained by giving the patient a purgative, then placing him on a strictly nonresidue diet for 4 or 5 days, and giving him daily enemas. A cathartic the day before operation is harmful, because it clears out the solid material but leaves in the bowel a liquid which is not only more highly infective but is more fermentable. The only efficient method to prevent distention from swallowed air is to insert a nasal catheter with constant gastric siphonage, as advocated by Wangensteen. It is rare that the surgeon feels this is necessary in an ordinary laparotomy; however, in an obese person, for example, with a large postoperative ventral hernia the procedure is well worth while.

When a patient's abdomen is distended 48 hours or more following a laparotomy and he is in distress, there may be 1 of 3 abdominal causes. The distention may be due to postoperative atony, to paralytic ileus as a result of infection within or close to the abdominal cavity, or to mechanical obstruction. At the outset it is not possible to be certain as to which is responsible; most likely in an uncomplicated laparotomy it is the first, and treatment is instituted on the basis of this assumption. There are ordered in succession, a rectal tube, ordinary enema, irritative enema, morphine, and, if necessary, constant gastric suction. At times these measures are not effective. Although at this stage the clinician begins to wonder if there is not present something more serious than simple postoperative atony, he at the same time casts about for some more effective means of expelling the gas. That pituitrin or pitressin under these circumstances will relieve distention is by no means a new observation. However, the physician sometimes hesitates to use it for fear of spreading a localized peritonitis or aggravating an intestinal obstruction.

We have made records of the distention immediately following the use of pitressin in 15 patients who 48 hours after operation developed distention, which we were unable to relieve by a rectal tube.

In order to determine the variations in abdominal distention in these and subsequent cases frequent measurements were made of the abdomen. Points of measurement were established by marking with mercurochrome

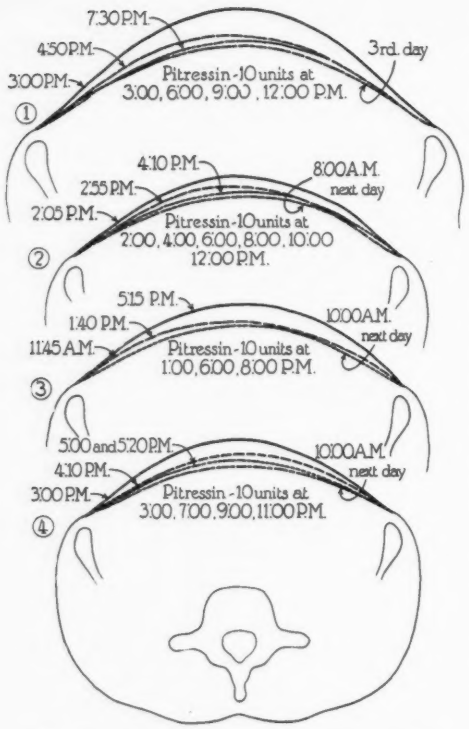

Fig. 2. Beneficial effect of pitressin on distention due to atony occurring 48 hours after operation. *1.* Operation performed to free adhesions causing pyloric obstruction. Two days after operation distention was quite marked. A rectal tube was ineffective. One and one-half hours after the first injection of 10 units of pitressin, there was a sharp reduction in distention. Note that approximately the maximum effect was produced by the first dose, and that this measurement is comparable to the measurement made 3 days later when patient's condition was normal. *2.* A suprapubic hysterectomy and appendectomy. Forty-eight hours after operation distention was not relieved by a rectal tube. In addition 10 units of pitressin was given every 2 hours. There was an immediate reduction in distention and in discomfort, neither of which recurred. *3.* A panhysterectomy. Distention and discomfort on the third day. An injection of 10 units of pitressin was given plus a soap suds enema. The size of the abdomen, instead of being decreased, was increased, returning to the original on the following day. This is 1 of only 2 patients in this series whose distention was not relieved by pitressin. *4.* A supracervical hysterectomy. Distention which appeared on the third day was not relieved by a rectal tube, but when injection of pitressin in 10 unit doses was begun it was sharply reduced. Note again that approximately the maximum effect was produced by the first injection. Subsequent injections, 5 in number, were probably unnecessary.

a spot on the skin just above each iliac crest in the midaxillary line. A lead tape was then laid over the abdomen between these points so that its curve would correspond to the abdominal curvature. It was removed and the resulting curve traced on a sheet of paper. In this way we had but a crude method of determining distention; however, the record obtained proved much more satisfactory than the impression gained from examining the abdomen. In this series there were performed 18 pelvic laparotomies, 2 vaginal hysterectomies, 2 recurrent ventral herniotomies, 1 appendectomy, and 1 nephrectomy. Repeated measurements were made upon these patients immediately after the injection of pitressin. In all but 2 instances there was a definite reduction in the abdominal measurement followed by subjective relief. A fairly good composite picture of what happens is shown in Figure 2, *4*. In about an hour after the first injection the distention is diminished. If a second injection is given there is usually very little further reduction in the measurement. The abdomen remains flat on the following day. A rectal tube is necessary to obtain good results; and a better result may be obtained if an enema is given about 15 minutes after the pitressin is injected. The dosage cannot be standardized. We have used for the most part 10 pressor units intramuscularly; 20 units is certainly more effective, but in our experiments on normal individuals we not infrequently found violent contractions associated with severe pain when we used 20 units. In small individuals, or when the need is not great, it is probably better to give 10 or 15 units. If there is no effect, a second dose of 20 units could be used an hour later. If after 2 injections there is no improvement, it is unlikely that pitressin will prove effective in that particular case. If a few injections combined with a rectal tube are not effective one can promptly suspect that there is a more serious basis for the distention than mere postoperative atony. If there is peritonitis or obstruction will pitressin cause harm? We have used it in peritonitis frequently enough to be of the opinion from clinical observations that it does not spread a peritonitis. If only a few injections are used it is very unlikely that harm will result. If the bowel is paralyzed by a peritonitis it is even unlikely that there will

be any effect on the bowel whatever. We have not made enough observations on the following point to be absolutely sure, but as a rule if on auscultation of the abdomen no peristaltic sounds are heard the pitressin is ineffective. If the abdomen is distended and peristaltic sounds are present it is effective. There can be no denying that such a peristaltic stimulant would be harmful if intestinal obstruction were present. Two patients with postoperative obstruction were given pitressin every 4 hours. Both of them required a second operation for relief, but in neither case could we observe any marked exaggeration of the symptoms. Since the effect wears off soon, if one does not persist in administering the drug probably little harm will ensue.

Conclusion. Pitressin given in 10 or 20 units, combined with a rectal tube is effective in postoperative atony. A few injections produce results; if they do not, the distention is probably due to either a peritonitis or to an obstruction. If one does not persist in the use of pitressin, it is doubtful that any harmful effect can be produced.

ROUTINE USE OF PITRESSIN BEFORE AND AFTER OPERATION

There have been several reports on the beneficial effects of pitressin when used in a routine measure before and following laparotomies. Bidwell gave pituitrin every 4 hours after 21 laparotomies. All the patients passed gas within a few hours after the first injection, and were free from any abdominal pain or distention. Potter (42) has reported favorable results from the routine use of pitressin in 1,200 cases. He recommends an intramuscular injection of 20 units before operation and then at approximately 4 hour intervals for 2 or more days. He aims to begin the injections when the bowel is not distended and thus never allow it to become distended. When it is given before operation, he has noticed that the small bowels contract down in 15 to 20 minutes, thus making them easier to handle and also making the closure easier (43). Black used it in 60 laparotomies and found a definitely contracted gut which was much easier to handle during the operation and the closure.

To evaluate the effect of any form of therapy upon abdominal distention is a difficult matter. One of us (F. H. F.), operating on gynecological cases only, used pitressin before and after operation on alternate patients The untreated patients were used as controls.

The pitressin series consisted of 14 suprapubic operations and 2 vaginal operations; the controls, of 15 suprapubic operations and 1 vaginal operation. One and sometimes 2 ampuls of pitressin were given ½ hour and just before operation in order to determine the effect on the gut. The intestines cause relatively little trouble in gynecological cases and observations on the small intestine are not as easily made as in upper abdominal operations. There was a tendency for the bowel to be more contracted, but the difference, quite definite in some, was more or less conjectural in others. It is probable that there was some contraction in every case, but it was not sufficiently marked so that the operator could determine clinically which patient received pitressin and which one did not.

Immediately following operation 10 units or 20 units were given every 4 hours for 9 injections. Daily measurements of the abdomen were made to determine the amount of the distention in the 2 series. After any laparotomy the abdomen becomes more or less distended and the amount of measured distention is by no means a criterion as to the amount of distress the patient has. The measurements, on the whole, showed that the pitressin series had less distention than the control series. A measurement was taken immediately after operation, followed by daily measurements. By measuring the curves we were able to calculate the average number of centimeters the center of the abdomen was distended above or below the first measurement. In the controls, the abdomen became slightly distended until the fourth and fifth day when it flattened out. In the pitressin series the abdomen never distended. In fact, on the third day the measurement was less than on the first. Although the pitressin series had a tendency to be less distended, the most marked difference, which occurred on the third day, averaged less than 1 centimeter, which is not enough to be of any significance. The postoperative abdominal

discomfort was about equal in the 2 series, as were the number of enemas and the number of injections of morphine that were required. There was no effect in this and other series in alleviating urinary retention.

In another series of 40 relatively uncomplicated operations pitressin was used prophylactically as a routine measure. The dosage varied considerably but averaged 6 to 7 ampuls of both 10 units and 20 units every 4 hours. There were 31 pelvic laparotomies, 4 cesarean sections, 3 tubal pregnancies, 1 pyloric obstruction due to adhesions, 1 gastric resection. In none of these patients was there any marked distention according to measurements. They were operated upon by various surgeons, and observations were made by various individuals. The consensus was that its routine use aided in the control of distention and made the patients more comfortable: the effect, though not marked, was beneficial. In the 4 cesarean sections and 3 tubal pregnancies recovery was remarkably uneventful; there was not the slightest distention and very little postoperative discomfort. A few patients had severe cramps following each injection, a few felt nauseated, pallor occurred in nearly every patient who received 20 units, and vomiting occurred in 3. Beyond this there were no untoward events that could be attributed to the pitressin.

Conclusion. Pitressin given pre-operatively has a tendency to contract the bowel. Its routine use after operation tends to reduce somewhat the amount of distention and discomfort following operation. Neither effect is sufficiently important to make its use in this manner mandatory.

PITRESSIN IN PERITONITIS

The postoperative treatment of peritonitis consists largely of the use of parenterally administered fluids, constant gastric siphonage, and morphine. Formerly many surgeons made rather violent attempts to move the bowels and relieve the distention. At present, most surgeons try to promote intestinal quietude in order to allow the infection either to subside or to localize. The marked distention of the gut in peritonitis produces a nutritional impairment of the bowel wall and is a very important factor in causing death. Attempts to control it completely are unsuccessful. Decompression by constant gastric suction and a rectal tube are the only measures that are of much help. Pituitrin and its active component, pitressin, have been frequently recommended in peritonitis (2, 8, 27, 40, 52). Potter (41) reports its use in 222 cases of acute appendicitis with and without peritonitis with a reduction in mortality rate to 4 per cent. Berry attributes to its routine use a reduction in mortality rate in acute diffuse peritonitis from 35 per cent to 17 per cent. On the other hand, Davis and Owens found pituitrin of little value in cases complicated with peritonitis.

In various wards throughout the hospital pitressin was used for patients who already had a peritonitis. In all of these cases the individual was extremely ill, many times *in extremis*. In this manner it was used persistently, 3 to 5 ampuls daily, in the following 36 cases: There were 16 postoperative gynecological cases with 10 deaths; of these, 7 patients had localized abscesses in the pelvis and only 2 died. There were 2 patients with post-abortion peritonitis, both of whom died. There were 2 patients with ruptured duodenal ulcers; 1 died a week after operation apparently from a localized abscess; the other died in 8 days of delirium tremens, and at autopsy there was no evidence of peritonitis. Two patients with peritonitis of unknown cause and 1 with a thrombophlebitis did not recover. Three patients operated upon for appendicitis recovered, 1 had a localized abscess in the right lower quadrant. Two patients who underwent gall-bladder operations recovered: 1 had an abscess of the gall bladder, the other a bile peritonitis. Although these last 5 cases had intraperitoneal infection over a considerable area, one cannot say that it was generalized. Nine patients who were operated upon for hypertrophied prostate developed marked distention, in what part due to general or local peritonitis or uremia it is hard to determine. In some of them the distention was improved, but only 1 recovered. The entire group consists of 36 cases with 12 recoveries. Those who obviously had a severe spreading peritonitis number 18 with 1 recovery. In spite of

this tremendous mortality rate, from clinical observation it was felt that 1 patient had probably been made worse by the use of pitressin, but that the others were made neither better nor worse. All of them had constant gastric siphonage, continuous intravenous administration of fluids, and morphine.

From a study of the measurement of the abdomen it becomes clear at once that pitressin is not very effective in reducing distention of the bowel caused by either a local or general peritonitis. Figure 3, showing the measurements following its use in peritonitis, is much different from that following simple postoperative atony. As a rule there is no relief of the distention, and if there is improvement it does not persist. True, at times 20 units of pitressin plus an enema causes the expulsion of large quantities of gas with some subjective relief. Vogt and Elmer, Ptaszek, and Scheps recommend its intravenous use. Vogt used intravenous injections with constant intravenous administration of dextrose and saline in 81 cases of postoperative ileus with 18 recoveries. He invariably obtained expulsion of the intestinal contents along with rather sharp vasomotor reactions. It seems to us that intravenous injection is too drastic treatment.

Conclusion. Possibly the stirring up of intestinal activity by pitressin is harmful, possibly it is not harmful. From our experience we cannot say, but we do believe that a patient with peritonitis will recover or die regardless of whether he does or does not receive pitressin.

SUMMARY

1. By insufflating a normal individual's colon it is definitely shown that pitressin produces powerful colon contractions.

2. Pitressin in 10 or 20 unit doses combined with a rectal tube quickly flattens out the abdomen in simple postoperative atony. Twenty units is an ample dose, and at times it is too much.

3. The secondary effects of pitressin on the vascular and urinary systems are relatively unimportant in ordinary therapeutic doses but they should be kept in mind.

4. The routine use of pitressin before and after laparotomies was not notably beneficial in a series of well controlled cases.

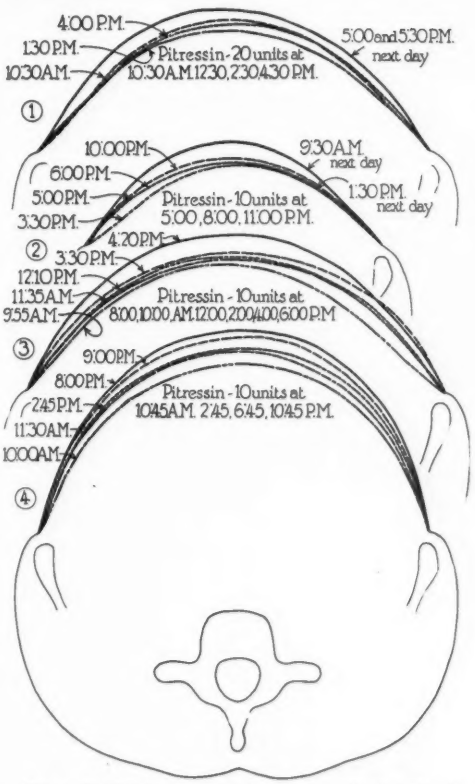

Fig. 3. Ineffectiveness of pitressin in relieving the distention of peritonitis. *1.* A 36 year old woman developed a generalized peritonitis following a panhysterectomy. Six days after operation 4 doses of pitressin in 20 unit amounts were given every 2 hours. One hour after the second injection the measurement decreased somewhat, but after the third injection it returned to its original size. The following day the abdomen was distended more than ever. The patient died 19 days after operation. *2.* A general peritonitis appeared 2 days after dilatation and curettage. After 13 days the patient's condition was very grave. In spite of 3 injections of 10 units of pitressin, the distention increased; on the following day it was more markedly increased. A second series of 3 injections produced a very temporary reduction. This patient died 17 days after the onset of peritonitis. *3.* A severe peritonitis was present 2 days following a vaginal hysterectomy. Every 2 hours 29 ampuls of pitressin in 10 unit doses were given. The abdomen steadily increased in size. The next day a 1–2–3 enema was quite effective in reducing the distention, but it rapidly recurred. This patient died 5 days after operation. *4.* For 7 days after a vaginal hysterectomy this patient was very ill and had the large, tense abdomen of a generalized peritonitis. Injection of pitressin in 10 unit doses was begun and given continuously every 4 hours. The abdominal measurement steadily increased. The next day pitressin and an irritative enema, milk and molasses, were of benefit in relieving the distention but not in improving patient's general condition. Death occurred 9 days after operation.

5. Its administration after the onset of peritonitis did not influence the outcome for better or for worse.

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THE PHENOMENON OF LIGHTENING IN PREGNANCY AND THE LOWER UTERINE SEGMENT

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OBSERVATIONS made on the condition of the lower uterine segment during the performance of cesarean section and a consideration of the mechanism of the engagement of the presenting part have caused an investigation into the formation of the lower uterine segment and its clinical significance. During the performance of cesarean section the vertical length of the lower uterine segment observed before and after the onset of labor, and the station of the presenting part have been so variable that the problem is, how is the lower uterine segment related to the phenomenon of lightening? When does it manifest itself clinically and what is its clinical importance? I believe that the phenomenon of "lightening" is primarily due to the final physiological phase in the preparation of the lower uterine segment for parturition. Physiologically and clinically the early formation of the lower uterine segment is manifested by the Hegar's sign of pregnancy. The descent of the presenting part into the pelvic cavity is a passive process due to the active relaxation of the lower uterine segment and is clinically known as the phenomenon of lightening.

The purpose of this paper is to analyze the phenomenon of lightening and to consider all the possible causative factors that may be concerned and to offer new explanations based upon anatomical, physiological, and clinical grounds.

A brief review of the literature will suffice to indicate the current views relating to the cause of the phenomenon of lightening. DeLee writes that the uterus sinks gradually downward and forward. This leads to a gradual sinking of the fetal head into the true pelvis. The formation of the lower uterine segment may be a part of the process. Edgar, Eden and Holland, Peterson, Shears, and Galabin and Blacker ascribe lightening to the descent of the uterus with the presenting part into the true pelvis. Edgar further suggests that descent is due to the gradual relaxation of the soft parts. Webster states: "It is often noticed that during the last month of pregnancy the fundus sinks somewhat. In primiparæ this is generally due to the sinking of the uterus vertically as a whole (clinically this is described as a sinking of the fetal head within the true pelvis). The reason for the sinking of the uterus as a whole in primiparæ is the strength and resistance of the abdominal wall; as the uterus increases, it is forced in the direction of least resistance, i.e., downward." Solomons states: "Lightening is probably due to the dilatation of the lower uterine segment, providing new space for the liquor amnii, with consequent descent of the fundus, and at this time the head usually passes into the pelvis."

The chief features of the phenomenon of lightening are a descent of the presenting part into the true pelvis and an exaggeration of the anterior tilting of the uterus when the patient assumes a standing posture, which gives subjective relief from the symptoms of intra-abdominal tension.

The possible mechanisms concerned in the phenomenon of lightening which are discussed in the literature and which occur to the author, are: (a) the formation of the lower uterine segment, (b) the relaxation of the soft parts of the pelvis, (c) the great mobility of the posterior uterine attachments, (d) the adaptive relaxation of the muscles of the abdominal wall analogous to that which occurs on the ingestion of a meal, and (e) the cephalopelvic relation.

THE CAUSE OF THE DESCENT OF THE PRESENTING PART

During the last month of pregnancy and usually concomitant with the phenomenon

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of lightening, the presenting part descends into the pelvic cavity. The problem is to determine whether the descent is due to (a) relaxation of the lower uterine segment, or (b) a sinking downward of the uterus caused by a relaxation of the pelvic floor and the uterosacral and uteropelvic ligaments, or both.

FORMATION OF LOWER UTERINE SEGMENT

In regard to the rôle played by the lower uterine segment in the phenomenon of lightening, two questions immediately arise, namely: at what time does the lower uterine segment become recognizable anatomically and clinically, and does it definitely relax more or less abruptly and concomitantly with the phenomenon of lightening?

When does the lower uterine segment become evident anatomically? A study of frozen sections demonstrates that the lower uterine segment becomes progressively more and more evident from the second month of pregnancy to term. Von Franque has studied 177 frozen sections, 34 uteri of his series and the balance from the literature, and found that the lower uterine segment was present in uteri from the second to the tenth month of pregnancy. The lower uterine segment measured vertically as follows: second to fourth month, 2.3 centimeters; fifth to sixth month, 4.1 centimeters; seventh to tenth month, 6 centimeters; and during labor it varied from 3 to 10 centimeters in different specimens. Testut and Blanc reported that the lower uterine segment is present in all gravid uteri irrespective of the month of gestation. Benckiser found, on studying frozen sections, that the lower uterine segment is present in 4 month pregnancies. Webster in a fifth month frozen section found a well differentiated upper and lower uterine segment. Bayer, Leopold, and Hofmeier found the lower uterine segment in frozen sections from the third month to term. Acosta-Sison reported that the lower uterine segment begins to appear soon after implantation. Thus, anatomically, the lower uterine segment may be recognized soon after implantation and may be considered as present clinically when the Hegar's sign can be elicited.

To ascertain how well the data from frozen sections check with the living anatomy, measurements of the vertical width of the lower uterine segment were made during the performance of the low cervical cesarean section at or near term. When cesarean section is performed before the onset of labor, one cannot usually observe by inspection and palpation the junction between the two uterine segments. But, after the child has been delivered and the upper uterine segment has undergone retraction, it is frequently found that the hysterotomy incision may extend some 2 or 3 centimeters into the upper uterine segment. However, if the section is performed after several hours of labor and if retraction of the upper uterine segment and cervical dilatation have occurred, the physiological retraction ring or the junction between the two uterine segments can usually be determined accurately. When the distance from the uterovesical reflection of the peritoneum to the physiological retraction ring or to the fixed anterior uterine peritoneum is measured before making the hysterotomy incision, either before or after the onset of labor, it is found to be from 6 to 14 centimeters (38 cases). The distance tended to be greater after labor had begun. These measurements check rather well with those from frozen sections.

Does relaxation of the lower uterine segment account for the descent and for part of the phenomenon of lightening? That Hegar's sign represents clinically the initial stage of the formation of the lower uterine segment is generally accepted (6, 9, 10, 22, 31, 32). This should be anticipated because after the implantation of the ovum the muscle fibers of those portions of the uterus which are later to form the upper and the lower uterine segments undergo hypertrophy and some hyperplasia. The growing ovum of the first 6 weeks of gestation normally occupies the uterine cavity above the physiological retraction ring or the anatomical internal os of Aschoff (2). At about the seventh week of gestation, the beginning of the fetal stage (embryos between 15.5 and 16 millimeters), some dilatation of the anatomical internal os and vertical lengthening of the isthmus uteri occur. This progressive change continues so that by the end of the first trimester, the uterus is a globular organ with the fetus occupying the upper and

the lower uterine segments. Thus, we believe that the anatomical internal os by dilating and ascending reasonably, and possibly on the basis of a study of frozen sections and comparative anatomy and physiology (24, 25), becomes the retraction ring of Barbour and Lusk or the contraction ring of Schroeder, or preferably the physiological retraction ring (23). At the end of the thirty-sixth week or thereabout the lower uterine segment may be physiologically differentiated, so that in response to an increase in intra-uterine pressure or some other stimuli, it may manifest its normal response of relaxation to accommodate the growing ovoid or the adjustment of the fetal posture for its coming part in the mechanism of labor; thus, leading to some descent of the presenting part, but to no retraction or thickening of the upper uterine segment. Interpreted in this manner the phenomenon of lightening should be a favorable clinical sign in indicating that the lower uterine segment is ready to perform its function.

If the descent and a portion of the phenomenon of lightening are due to relaxation of the lower uterine segment, this should be borne out by observing the cervix to be more flattened out against the presenting part and by a decrease in the distance between the cervix and the fundus uteri in the prone position. There is ample evidence in the literature showing that both occur after the phenomenon of lightening.

Yet, the phenomenon of lightening may occur without a decrease in the height of the fundus uteri, regardless of whether the presenting part is in the pelvis in normal cephalopelvic relation. The author has found the MacDonald measurement to be about 32 centimeters at the thirty-sixth week of pregnancy and about 33 centimeters at term whether the presenting part is high or low in the pelvic cavity. This has been observed by others (15, 19, 28). In 2 other patients the MacDonald measurement was 26 centimeters at term; 1 was delivered of a small child weighing 6½ pounds, and the other of a child with an encephalocele. When the MacDonald measurement was greater than 35 centimeters the cause was either a frank breech (either high or floating), hydramnios, twin pregnancy, monstrosity, cephalopelvic disproportion, pelvic neoplasms, or obviously "absence of the phenomenon of lightening." Such observations complicate the explanation of the phenomenon of lightening. If the presenting part is high, the phenomenon of lightening must have been due to relaxation of the abdominal muscles (*vide infra*). If the head is low, and the phenomenon of lightening has been experienced, but the fundus is high, there must be either an increased amount of amniotic fluid or the fetus must be more extended than normally due to contraction or shortening of the circular muscle fibers of the uterus, giving the uterus a more cylindrical form. Of course, if the position of the presenting part varies considerably between the prone and upright positions and the cervix is flattened out, this would indicate considerable softening or relaxation of the pelvic supports.

Relaxation of the soft parts of the pelvis. Obviously a relaxation of the pelvic soft parts may account for descent or at least a portion of it. In this connection the hormone *relaxin* (17), which is produced by the corpus luteum and plays such an important rôle in parturition in the guinea pig by softening the pelvic ligaments (separation of the pelvic bones), comes to mind. However, relaxin has not been found in the blood of pregnant women, although entirely adequate methods to determine its presence have not yet been employed. Yet, if the cervix descends concomitantly with the occurrence of lightening, this may contribute to the cause of the phenomenon.

Clinically it is known that when Hegar's sign becomes manifest the cervix is usually located somewhat higher than normally, but later descends to its original position. In unusual instances it may later descend so much that folding of the vagina occurs (9). Since it has not been shown that the fibrous ligaments actually soften in women, it may be postulated that the muscle fibers of the fibromuscular (uterosacral and uteropelvic) ligaments may be reflexly relaxed, possibly permitting some descent. In many parturients the cervix does not descend appreciably or significantly, and lightening must then be due to other factors. Yet, if the cephalopelvic relation is normal, the fetal head can be easily impressed

into the pelvic cavity according to the method of Muller-Pinard, Munro Kerr, or Hillis. So, the author believes that if the cervix shows no appreciable descent and the fetal head is floating or high, but may be impressed into the pelvic cavity, the absence of relaxation of the lower uterine segment is indicated, which is borne out by the examination of the cervix.

Thus, the foregoing analysis shows that the descent associated with lightening is due either to a relaxation, gradual or rather abrupt, of the lower uterine segment or to a softening or relaxation of the pelvic ligaments or both and is a significant phenomenon particularly in primiparæ and in multiparæ. A consideration of the variability in these factors explains the varying degrees of descent observed in normal cephalopelvic relations.

THE MECHANISM OF ANTEVERSION OF THE UTERUS IN LIGHTENING

The difference in the mobility of the anterior and posterior uterine attachments. The cause of the exaggeration of the anteversion following lightening must be due to (a) the natural tendency of the uterus toward anteversion and flexion, and (b) the relaxation of the abdominal muscles.

The natural tendency of the non-pregnant uterus toward anteversion and flexion is due to anatomical and physiological considerations. The anterior portion of the cervix is firmly fixed to the pubic segment of the pelvis through the anterior vaginal wall, which is 6.5 centimeters in length, by the endopelvic fascia, and the uteropelvic ligaments; while the posterior portion of the cervix uteri is attached to the sacral segment of the pelvis through the posterior vaginal wall, which is 9 centimeters in length, by the endopelvic fascia, and the uterosacral ligaments. Due to these anatomical relations of the anterior and posterior attachments of the cervix uteri, the anterior portion may be considered as the pivot of uterine mobility. A study of frozen sections demonstrates this anatomical relationship, especially the "second stage" sections of Braune, Chiara, and Barbour, and Webster.

This natural tendency of the non-pregnant uterus toward anteversion and flexion is manifested in early pregnancy and throughout pregnancy. After lightening, anteversion and flexion are exaggerated. Further, during labor, with each uterine contraction, the uterus undergoes varying degrees of erection, the anterior wall of the cervix being the pivotal point. The erection of the uterus with each uterine contraction must be due either to a greater contraction and retraction of the longitudinal muscle fibers of the anterior uterine wall or to a greater "giving" of the attachments of the posterior wall of the cervix, or both. That the posterior attachments "give" more than the anterior during labor is demonstrated by the analysis of the measurements from the frozen section of Barbour and Webster (3) of the normal second stage of labor.

MEASUREMENTS OF BARBOUR AND WEBSTER

	Anterior uterine wall, centimeters	Posterior uterine wall, centimeters
Fundus to the physiological retraction ring	23.75	16.25
Physiological retraction ring to internal os	4.50	3.00
Internal os to external os	4.25	3.25
	32.50	22.50

The greater sustained contraction, or retraction, of the posterior portion of the uterine wall is necessary to take up the slack resulting from the giving or relaxation of the attachments. For the posterior cervical lip to reach the same level as the anterior cervical lip, the anterior uterine wall is more firmly fixed to the pubic segment of the pelvis.

The anterior uterine wall from the fundus to the physiological retraction ring measures 23.75 centimeters, which demonstrates that the *retraction of this portion is much greater than that of the posterior uterine wall;* because the anterior uterine wall must pull the posterior portion of the physiological retraction ring up to its anterior level, which is shown by the posterior uterine wall, from the fundus to the physiological retraction ring, it measures 16.25 centimeters. The anterior uterine wall is fixed to the pubic segment of the pelvis by the cervix uteri, so that the cervix uteri which is the pivot of anteversion of the uterus pulls the posterior uterine wall more anteriorly. Berry Hart (16) has pointed out that the

anterior uterine wall is about 6 millimeters thicker than the posterior uterine wall, so the greater retraction of the anterior uterine wall, and the pulling upward and outward of the posterior uterine wall bring the posterior uterine wall from the fundus to the physiological retraction ring to measure 16.25 centimeters. A consideration of the difference in the physiological changes of the anterior and posterior uterine walls demonstrates the equalizing phenomenon of the 10 centimeters difference in order to form the uterovaginal wall for the second stage of labor. This demonstrates the purposefulness of equalizing the physiology of the uterus in bringing about the harmonious function of the uterus in anteflexion and dilatation of the cervix uteri.

These measurements of Barbour and Webster demonstrate beautifully the compensatory changes which occur in different portions of the uterus and the birth canal, and that retraction is a remarkable phenomenon that is essential for the equalization of cervical dilatation. The natural tendency toward anterior tilting is still maintained even during the second stage of labor.

However, the fact that in a pendulous abdomen the uterus falls forward quite markedly, when the standing posture is assumed, shows that the posterior supporting structures and the "retractile tone" of the posterior uterine musculature are not sufficient to maintain the gravid uterus of the ninth month, or even before, in a semi-erect posture. Hence, it follows that the tone of the muscles of the anterior abdominal wall play the most important rôle in determining the degree of the anteversion in lightening. This, of course, is the conclusion of most obstetricians; but none have attempted a physiological explanation for the rather abrupt change (24 to 48 hours) in the tone of the abdominal muscles that is frequently observed.

THE ADAPTIVE RELAXATION OF THE MUSCLES OF THE ABDOMINAL WALL

The sudden decrease in tone of the muscles of the lower abdomen in lightening suggests to a physiologist that a reflex mechanism may be concerned and that a sudden change in the "level" of a reflex tonus mechanism has occurred. Such a change may also occur gradually. In this connection it is known that when a meal is ingested, not only does the stomach relax to receive the swallowed food, but the abdominal muscles also relax reflexly to prevent an increase in intra-abdominal pressure (7). It is highly probable that a similar relaxation of the abdominal muscles occurs during pregnancy. Coombs has made a study of pregnant cats. She found that in pregnancy there is a greater ability of the abdomen to accommodate more fluid at a low pressure than in the non-pregnant cat, and concluded: "We must acknowledge the intervention of a reflex nervous regulatory mechanism." The exact reflex pathway that may be concerned in such relaxation has not been determined, but Coombs' observations show that the nature of the mechanism is reflex. Because sensory fibers in the vagi or splanchnic nerves are most probably responsible for the relaxation of the abdominal muscles that occurs when a meal is ingested (7), it is possible that sensory impulses from the uterus or pelvic soft parts (via the pelvic nerves, or the lumbar sympathetics) are concerned in the production of the relaxation of the abdominal muscles in pregnancy. One cannot disregard the possibility that some of the relaxation may be due to the segmental reflex arcs that innervate the abdominal musculature, i.e., the stretch of the abdominal muscles stimulates the sensory nerve endings which maintain the tone of the muscle at different levels, and, at the ninth lunar month, the sensory impulses set the spinal center at a lower tonus level. This would be difficult to determine experimentally, however. That the segmental arcs are set at a lower tonus level is shown by the observations of Coombs; we are ignorant only of the mechanism. The explanatory hypothesis that appeals most to the author is that the lower uterine segment relaxes permitting the presenting part to descend and that sensory impulses set up by the relaxation of the lower uterine segment, or by the pressure of the presenting part on the pelvic soft parts, the latter being much more likely (*vide infra*), induce reflexly a relaxation or change in the tone of the abdominal muscles. A less likely hypothesis, when one con-

siders certain abnormalities (*vide infra*), is that when a certain abdominal pressure is reached, sensory nerves in the abdominal wall are stimulated and reflexly cause a relaxation of the muscles of the pelvic floor and the fibromuscular ligaments, a relaxation of the lower uterine segments, and a reduction of the tone of the muscles of the lower abdomen.

DISCUSSION

The consideration of the sequential changes of the pregnant uterus demonstrates the purposefulness of the vertical changes of the lower uterine segment and its final preparatory phase for parturition.

The mechanophysiological requirement of the pregnant uterus for its function of expulsion of the ovum as shown from the study of frozen sections is that the lower uterine segment is gradually increased in its vertical length. The anatomical fixation of the anterior portion of the cervix uteri to the pubic segment of the pelvis demonstrates the pivot of uterine mobility and the equalization of cervical dilatation by the difference in the retraction of the anterior and posterior uterine walls as established from a study of frozen sections of the second stage of labor, and particularly the measurements of the second stage frozen section of Barbour and Webster (*vide supra*). Comparative anatomy and physiology points to the homologous mechanophysiological features of all animals in labor.

The anteversion of the uterus is, therefore, based on anatomical and physiological considerations as to the normal position of the pregnant uterus. The exaggeration of the anteversion of the uterus after lightening, in either an acute or gradual manner, appears to be a logical explanation based on a reflex mechanism in causing the relaxation of the abdominal wall which is suggestive from the studies of Cannon and Coombs.

The clinical evaluation of the phenomenon of lightening can be readily correlated to the physiology involved. A normal cephalopelvic relation is the basis of the phenomenon of lightening. When it has occurred the fetal head is in the pelvic cavity, the uterus is more downward and forward, and the epigastric space is increased in size. The MacDonald measurement shows no change before and after lightening. I have demonstrated that the vertical increase in size of the lower uterine segment is a gradual one from nidation of fertilized ovum to term; frequently the lengthening is rapid in the last month of pregnancy. Therefore, this vertical lengthening is an active process of the lower portion of the uterus. A study of living pathology observed during the performance of cesarean section demonstrates the variable vertical lengths of the lower uterine segment and checks rather well with the knowledge gained from a study of frozen sections.

The clinical phenomenon of lightening is explained on the basis of the passive descent of the fetal head into the pelvic cavity by either an acute or gradual active vertical elongation of the lower uterine segment usually during the last month of pregnancy; the downward and forward dropping of the uterus is due to a relaxation of the abdominal muscles with no change in the MacDonald measurement which is due to the increased vertical length of the lower uterine segment, but no corresponding change in the upper uterine segment; and the increase in the epigastric space resulting in more comfort for the patient is due not to a descent of the uterus as a whole, but to the increased anteflexion of the uterus brought about by the relaxation of the abdominal muscles which causes an increase in the intra-abdominal space, and the fundus uteri only passing downward and forward brings about an increase in the epigastric space.

The clinical value of understanding the phenomenon of lightening will be briefly stated as follows:

In normal cephalopelvic relation the presenting part may be floating or high on account of the temporary delay in the phenomenon of lightening, which may occur during the last month of pregnancy, the first stage, or occasionally in the second stage of labor. The differential diagnosis of a functional or mechanical floating or high fetal head is determined by the impression method.

In cephalopelvic disproportion lightening may have taken place, but the mechanical factor is the cause of the floating or high fetal

head, yet the sign of the fundus uteri being downward and forward is present.

In distention of the uterus due to polyhydramnios and twin pregnancies, the phenomenon of lightening may have taken place, but on account of the tension of the lower pole of the uterus, which rests on the pelvic inlet, the presenting part and the cervix uteri are found to be high.

In placenta previa, the progressive change of the lower uterine segment explains the painless, causeless uterine hemorrhage that may occur at any stage of pregnancy from the formation of the placenta (third to fourth month) when it is unavoidably separated from the lower uterine segment. In this connection we may reasonably assign some cases of abortion occurring between the third and fourth month of pregnancy as being due to placenta previa.

SUMMARY

The lower uterine segment is mainly demonstrated clinically by Hegar's sign of pregnancy; the phenomenon of lightening and the engagement of the presenting part which takes place during the last month of pregnancy are acute manifestations of the final physiological phase of the preparation of the uterus for parturition. The phenomenon of lightening, therefore, consists of (a) the final physiological phase of the formation of the lower uterine segment, (b) the passive descent of the presenting part into the pelvic cavity, and (c) the pressure of the presenting part or the final physiological phase of the relaxation of the lower uterine segment, which excites a reflex nervous mechanism that is responsible for the more or less abrupt relaxation of the abdominal muscles which is the cause of the exaggerated anteversion of the uterus that occurs on assuming the standing posture. In those cases in which the phenomenon of lightening occurs gradually, the descent of the presenting part into the pelvic cavity and the reflex mechanism respond progressively and not abruptly. Apparently in all conditions which prevent a descent of the presenting part into the pelvic cavity, the phenomenon of lightening does not result or is not strikingly evident.

CONCLUSIONS

1. The phenomenon of lightening is related to the formation of the lower uterine segment.
2. The lower uterine segment is clinically recognized early by Hegar's sign of pregnancy.
3. Normally, the lower uterine segment progressively elongates vertically from the sixth week of pregnancy to term.
4. The phenomenon of lightening which occurs in the last month of pregnancy is due to the final physiological phase in the formation of the lower uterine segment which passively allows the presenting part to descend into the pelvic cavity when the cephalopelvic relation is normal.
5. The falling forward and downward of the fundus uteri is due in part to a reflex relaxation of the abdominal muscles.
6. The lower uterine segment may be delayed in its final physiological phase to some time near the onset of labor, in the first stage, and occasionally in the second stage of labor.
7. The delay in the phenomenon of lightening explains the mechanism of hemorrhage in placenta previa occurring after the first trimester, or at any stage of pregnancy and labor.
8. Delay in the final physiological phase of the formation of the lower uterine segment is the differential diagnostic criterion between a functional and mechanical dystocia when the presenting part is high or floating.
9. Abortions and premature labors may be caused by an early phenomenon of lightening.

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CLINICAL SURGERY

FROM THE UROLOGICAL SERVICE OF THE BROOKLYN HOSPITAL

PRIMARY BLADDER TUMORS IN INFANT AND YOUNG CHILDREN

With Report of a Case of Hemangioma in a Male Child 27 Months of Age

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BLADDER tumors in infancy are among the rarest forms of pathological lesions noted in the urinary tract. Beer and Hyman state, "Tumors of the bladder in childhood are so rare that an extensive discussion of their symptomatology and treatment is scarcely necessary. . . . In some 500 personal observations, no tumor of the bladder was encountered in childhood." Deming, writing in 1924, made a very careful review of the literature and could find only 64 authentic case reports of bladder tumors occurring in the first decade of life, to which he has added 2 cases of his own. In this group only 18 patients were at the age of 2 years or under.

It is perhaps reasonable to assume that other cases have been noted and have not been reported and I have no doubt that, with better diagnostic facilities, including cystoscopes especially devised for infants, they will be recognized with greater frequency in the future. For the bibliography prior to 1924 and for complete data on the cases collected and reported by Deming the reader is referred to his original paper, as only a brief summary is herewith presented. Most of this group consisted of solitary case reports, very few writers having been able to report more than 1 case.

The pathological conditions which were found to be present in these cases are given in the following table:

TABLE I

	Cases
Sarcoma	37
Myxoma	16
Fibroma	5
Rhabdomyoma	2
Polyps (benign)	2
Dermoid	1
Papilloma	1
Myoma	1
Undetermined pathology	1

The last case is one reported by Judd from the Mayo Clinic. Dr. William F. Braasch very kindly looked up the records for me and found that the patient was a female child of 7½ years who had had bleeding from the bowel and bladder at intervals for several years. She was admitted to the hospital *in extremis,* died from uremia, and at autopsy there was found an hemangioma involving the rectum, sigmoid, and bladder. This case and my own, about to be reported, are, so far as I have been able to determine, the only cases of hemangioma of the bladder in infancy which are reported in the literature. Inasmuch as there might be some doubt as to the original site of the tumor in Judd's case, my own case is perhaps unique.

Of the cases in Deming's group, all but 6 (9 per cent) patients died either of their disease with or without having undergone operation, or the tumor was disclosed at autopsy as an incidental finding. Of the 6 cases reported as cured by surgery, there were 2 polyps, 1 fibroma, 1 fibromyoma, 1 polypoid sarcoma, and 1 fibrosarcoma. The mortality of the cases with operation was nearly 90 per cent. Concetti reported 9 cases in which patients were operated upon, with a mortality of 100 per cent. The 2 personal cases reported by Deming were (1) a myxoma in a child of 20 months who was subjected to cystotomy, diathermy, and radium, followed by recurrence and death; (2) a rhabdomyoma in a child of 21 months subjected to cystotomy, curettage and cautery, followed in a few months be recurrence, reoperation, and death.

The male sex predominates 2 to 1, which is somewhat less than the 5 to 1 ratio usually noted in adults.

The principal symptoms noted were hematuria, pain, and disturbances of urination. The hematuria was occasionally massive in type, more

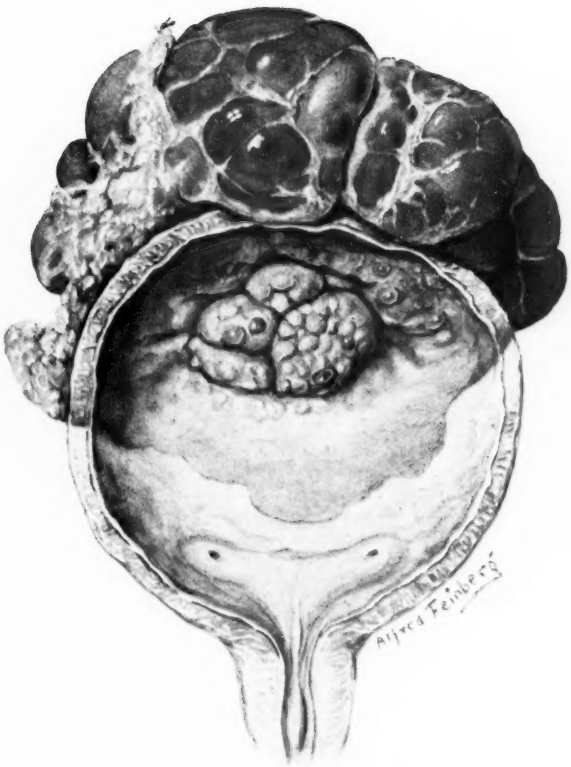

Fig. 8. Artist's conception of the tumor as it existed *in situ* made from specimen removed and description of operative findings—semi-diagrammatic. The lightly shaded portion is an effort to represent the tumor as it hung down behind the bladder wall.

Primary Bladder Tumors.—N. P. Rathbun

TABLE II

	Cases
Sarcoma	38
Myxoma	16
Myxosarcoma	4
Neurogenic sarcoma	1
Fibroma	5
Fibromyoma	1
Neurofibroma	1
Myoma	1
Rhabdomyoma	2
Polyps (benign)	2
Dermoid	1
Papilloma	1
Hemangioma	2

frequently terminal; the pain was often associated with urination in the form of a terminal dysuria. Frequency, dysuria, and bed wetting were often noted. The diagnosis was most frequently made on the symptoms plus a palpable mass detected by abdominal or recto-abdominal palpation. In only a few cases was the diagnosis assisted or confirmed by cystography and cystoscopy. This latter item is accounted for by the fact that many of the cases were reported before the day when practical cystoscopes for use in small children were available.

Since Deming's report I have been able to find 8 other cases in the literature; these with my case make a total of 75 cases reported to date.

A. Montenegro, writing in 1929, reports the case of a male child of 3 years with myxosarcoma of the bladder. He performed a cautery excision with rapid recurrence and death.

Again in 1929, E. Grynfeltt reports the case of a child of 9 months who was admitted to the hospital with a grossly overdistended bladder and a history of bleeding. A cystotomy was performed and the bladder was found to be nearly filled with a tumor mass. Nothing was done other than to place a tube in the bladder, and the child died in 2 months. The pathological report was myxosarcoma.

E. Ross Mintz, in 1931, reports a "round and spindle cell sarcoma, rapidly growing" in a male child of 5 years. He was subjected to cystotomy, diathermy, and radium. There was a rapid recurrence with death 1 year after operation.

E. W. White, in 1931, reports the case of a female child aged 7 years who complained of frequency and hematuria of 7 weeks' duration. At cystoscopy a small mushroom shaped growth was noted near the left ureteral orifice. A cystotomy was performed, the growth was clamped at the base and removed, and the base was fulgurated. The pathological report was fibromyoma. The child made a good recovery.

A. G. Weis and Raymond Meyer, in 1932, report the case of a male child of 4½ years who

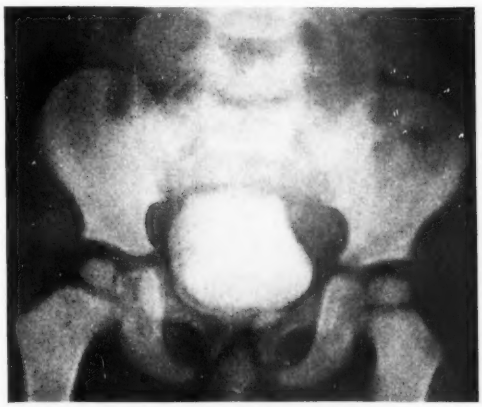

Fig. 1. Cystogram obtained as part of subcutaneous urogram. Note slight irregularity of upper border of bladder shadow. Suggestion of filling defect on the left.

was admitted to the hospital with the chief complaint of dysuria. A mass about the size of a large orange could be palpated over the pubis; bloody urine was passing in occasional dribbles. A right nephrostomy was done for drainage and the child died 1 week later in uremic coma. At autopsy there was found an extensive myxosarcoma of the bladder.

Lazarus and Rosenthal, in 1932, report the case of a male child of 2 years whose complaint was that of hematuria. Cystoscopy showed polypoid masses on the right lateral wall of the bladder. These were fulgurated cystoscopically with apparent improvement. Four months later there was a recurrence which was again fulgurated, followed by rapid recurrence; cystotomy, diathermy, radium, and Coley's toxins were all used, but death occurred 6 months after the operation was performed. The pathological report was myxosarcoma.

Koss, in 1934, reports the case of a male child of 7 years who suffered from von Recklinghausen's disease. On several occasions he had had a mild hematuria. He contracted scarletina, with a complicating bronchopneumonia, which caused his death. At autopsy there was discovered a neurofibromatosis of the bladder. Of course, this was not primary and perhaps this case should not be included.

Harvey and Tennant, in 1934, report the case of a female child 1 month of age who was admitted to the hospital *in extremis* with a mass in the lower abdomen extending halfway to the umbilicus. Autopsy disclosed a primary neurogenic sarcoma of the bladder.

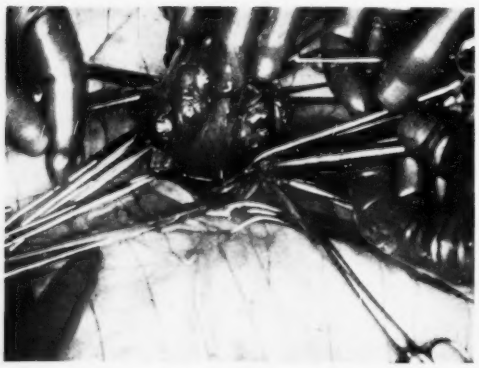

Fig. 2.

Fig. 3.

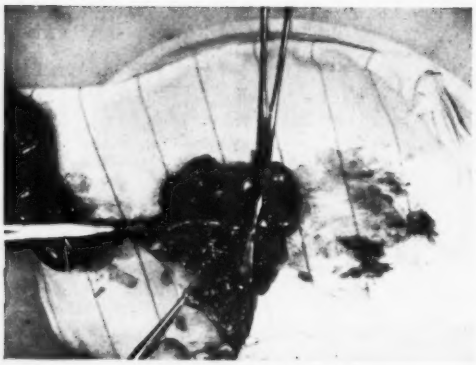

Fig. 4.

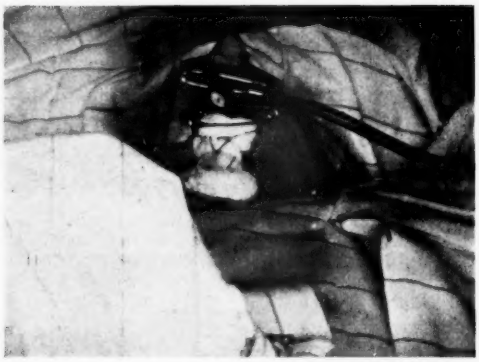

Fig. 5.

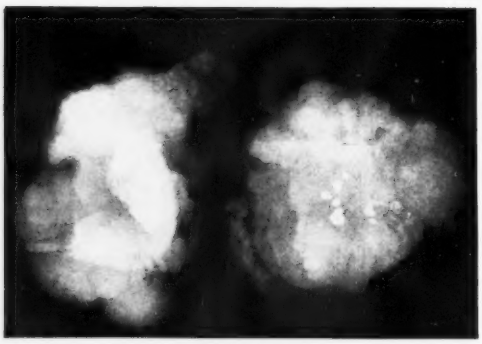

Fig. 6.

Fig. 2. This shows rather clearly the bladder and tumor as they appeared *in situ* at the time of the operation. The wound in the peritoneum is being closed. (This figure together with Figures 3, 4, and 5, was enlarged from a moving picture film of the operation.)

Fig. 3. Tumor and part of the bladder are about to be removed; the remainder of the bladder is seen in the depths of the wound, held up by artery clamps.

Fig. 4. Appearance of tumor immediately after operation.

Fig. 5. Closure with appropriate drainage and tension sutures.

Fig. 6. X-ray of tumor after its removal showing the small calcareous nodules. On reviewing the cystogram these were noted in the hollow of the sacrum above the bladder shadow. They had been missed at the first examination.

Adding the cases herewith cited and my own case, about to be reported, to Deming's list, the pathological process noted in all cases thus far reported appears in Table II.

Sarcomas and myxomas were by far the most frequent types of tumor that were noted and they were also found to be the most intensely malignant.

Following is a somewhat detailed report of my own case:

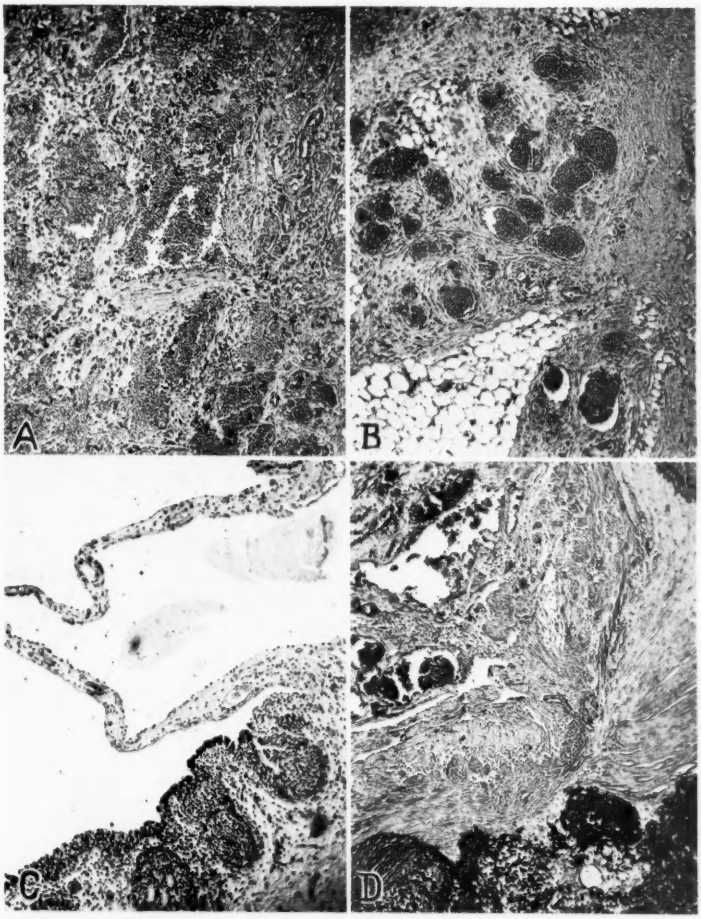

Fig. 7. Photomicrographs from various portions of the tumor. A, Well formed, blood filled vascular channels with rather thick connective tissue septa. B, Some adipose tissue, from the outer surface of the growth, containing groups of angiomatous spaces. C, Bladder muscosa on the inner surface of the tumor. In the upper portion of the field is a thin walled cyst. D, One of the denser areas composed chiefly of hyalinized connective tissue. Along the lower border of the field the tissue is calcified. A diagnosis of hemangioma was made.

The patient was a male child of 27 months who was admitted to the Urological Service of the Brooklyn Hospital on October 26, 1936. His chief complaint was hematuria which had existed, almost without intermission, for the past year. The general history was negative except for a mild attack of whooping cough at the age of 3 months. When the child was about 1 year old, the parents noted that on occasions he passed bloody urine; they also noted that the urine at the beginning of urination was clear, then became darker, and that the last drops were very bloody and apparently associated with considerable pain which caused the child to double up and cry. At this time he was taken to another hospital where circumcision was advised and performed. There was, of course, no improvement following the operation and the trouble continued with only occasional intermissions of a few days. During this period he had taken various remedies prescribed by the family doctor. In spite of this prolonged bleeding, he appeared on admission like a fairly healthy child, whose size and weight were normal for his age. The general physical examination was negative except that a soft indefinite mass could be rather vaguely palpated in the hypogastrium. The laboratory findings were as follows: urine, innumerable blood cells, no pus, and no casts. Blood examination revealed: hemoglobin, 55; red blood cells, 4,450,000; white blood

cells, 18,400; polymorphonuclear leucocytes, 73 per cent; bleeding time, 1½ minutes; clotting time, 6 minutes; grouping, IV. The tuberculin test was negative.

On October 29, 1936, under general anesthesia, a cystoscopy was attempted but was unsuccessful because even for his age he had a very small urethra which would not admit a No. 14 French double catheterizing cystoscope, which was the only child's cystoscope immediately available. Recto-abdominal examination at this time showed clearly a mass in the lower abdomen which appeared to be about the size of a large lemon and was fairly mobile.

On October 30, 1936, he was given a clysis consisting of 50 cubic centimeters of skiodan in 150 cubic centimeters of saline solution, and roentgenograms were made at intervals of 30, 45, 60, and 90 minutes. The kidney pelves were faintly outlined at 30 minutes, and were better outlined at 1 hour. The upper urinary tract appeared normal except for a very slight dilatation of the left kidney pelvis. The cystogram (Fig. 1) was very clear. It showed a slight irregularity of the upper margin of the bladder shadow with a suggestion of a filling defect on the left lateral wall.

On November 5, 1936, again under general anesthesia, another cystoscopy was undertaken. On this occasion a No. 9 French child's cystoscope was readily passed into the bladder and a rather extensive solid appearing tumor mass was noted which appeared to occupy the dome and upper portion of the posterior wall of the bladder.

On November 9, 1936, he was given a direct transfusion of 250 cubic centimeters of blood.

Operation was performed on November 10, 1936, under ether anesthesia by the open mask and drop method. An incision was made from the symphysis to the umbilicus. This immediately exposed the tumor mass which appeared to arise by a broad base from the dome of the bladder and to extend upward. The urachus was identified, tied, and cut. The peritoneum was deliberately opened. Through this opening the tumor could be readily palpated extending down behind the bladder, but it had not invaded the peritoneal cavity. The peritoneum was stripped off the tumor and bladder and the opening was closed. It was then fairly easy to mobilize the tumor and upper portion of the bladder. They were delivered out of the wound and amputated, the incision being carried well wide of the growth. This involved removing rather more than one-third of the bladder. This, however, left a fairly sizable bladder, which was closed around a small mushroom-shaped catheter. One cigarette drain was placed behind and another in front of the bladder and the wound was closed around the drains.

Figures 2, 3, and 4 illustrate the various stages of the operation and show also the appearance of the tumor *in situ*. The operation required an hour. The patient appeared in good condition but he was given another small transfusion of 120 cubic centimeters of blood.

The tumor when sectioned immediately after removal appeared fairly solid, and there were scattered through it a number of very small bony hard masses; at first we thought that these masses were bone and that we were dealing with a dermoid. They are clearly visible in a roentgenogram (Fig. 6) made of the tumor.

The child made an uncomplicated recovery. The suprapubic tube was removed on the ninth day. Two days later he was voiding all of his urine via the natural channels and he was discharged 3 weeks after operation with the wound entirely healed.

The pathological examination of the specimen removed was made by Dr. J. Arnold DeVeer and his report follows:

Gross. The specimen consists of the fundal portion of the bladder, the seat of a multilobulated cystic tumor. The entire specimen weighs 90 grams. The tumor extends through the entire thickness of the bladder wall presenting intravesicular and extravesicular portions. The mucosal surface of the growth is reddish-brown and finely nodular, resembling somewhat the papillated surface of the base of the tongue. Several deep fissures subdivide this tissue into irregularly shaped islands or lobules. Most of the small nodules are semi-translucent and of firm consistency, while others are thin-walled, bright red blebs filled with serosanguineous fluid.

The bulk of the growth lies like a cap over the outer surface of the bladder wall. It measures approximately 7 by 6 by 4 centimeters in major diameters. It is made up of coarse cystic lobulations, the individual cysts varying from a few millimeters to 2 or 3 centimeters in diameters. The cyst walls are, for the most part, thin and of a purplish hue. On section, the tumor structure is suggestive of a sponge with spaces of varying size intercommunicating freely. The dividing septa are of varying thicknesses and these occasionally unite to form fairly solid masses of supporting tissue. Several small calcareous bodies are found in these denser areas. The cyst contents vary from fluid which has the appearance of whole blood to a clear, blood-tinged watery lymph.

Microscopic. Sections from characteristic portions of the tumor show it to be of hemangiomatous structure throughout. Over the surface of the intravesicular portion is a somewhat irregular layer of bladder mucosa. Occasional thin walled cysts protrude beyond the general level of the mucosa (Fig. 7, C). The vascular channels are lined with adult endothelium and are separated by rather abundant connective tissue. Focally, this stroma is dense and hyalinized and, in a few places, calcified (Fig. 7, D). Remnants of bladder musculature are found among the vascular spaces. Most of the spaces are filled with blood, while the remainder contain faintly pink-staining fluid or have been completely evacuated. No lymphoid tissue is seen.

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FRACTURES OF THE HUMERUS

A Functional Method of Treatment

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IN HUMERAL fractures, especially the spiral shaft variety, the problem of management has always been enhanced because respiration deterred complete immobilization of the upper fragment. Furthermore, through current practice of treating these cases with traction in recumbency, or in an abduction airplane splint, or immobilization in a spica cast, numerous technical difficulties are presented to the doctor, while the patient suffers physical and financial problems as well. However, with a new transfixion technique, by which means absolute control of both upper and lower fragments is attained, efficient treatment has been so simplified that only a short plaster cast from shoulder to elbow is required for full immobilization. Hence, the patient may be immediately ambulatory, completely dressed, with free use of all joints of the arm.

The crux of this simplified system depends upon a specialized form of skeletal countertraction (Fig. 2). The transfixion of the upper fragment, at first thought, may seem inadvisable, but when half-pins are inserted into the neck of the humerus from the lateral aspect, the procedure is found not only anatomically safe but practical in operation. The half-pins, as their name implies, pass only halfway through the arm, although they completely transfix the humerus. The clamping bar through which these pins are angularly inserted and to which the exposed ends are fastened, furnishes an external bone clamp for manipulation of the superior fragment. On completion of reduction, the half-pin unit—the 2 half-pins and the clamping bar—is embedded in the plaster cast, literally nailing the upper fragment to the cast. Hence, neither respiratory nor shoulder joint movements can alter apposition. It is evident that this half-pin unit supplies a triple purpose: (1) skeletal countertraction, (2) a bone handle for manipulation, and (3) positive immobilization.

Traction is similarly obtained through half-pins transfixing the lower fragment. Insertions through the distal humerus may also be safely and easily performed, provided the bone is approached from its posterior aspect just above the elbow joint (Fig. 3). The distal transfixions have their threefold purpose: (1) skeletal traction, (2) a forceps for direct manipulation of the distal fragment, (3) absolute immobilization.

Traction force may be obtained through manual or mechanical means—the fracture table and the anatomic humerus splint, the two principal alternatives. The splint is preferable to the fracture table in that practically perfect apposition can be achieved through mechanical adjustments of an apparatus constructed on an anatomicophysiological basis (Fig. 5). The anatomic humerus apparatus has been devised so that each fragment can be separately manipulated or rotated in every direction, all upon the normal anatomical axis. Manipulations of the upper fragment are made with the humeral head as the center, while the lower fragment rotates with the center of the shaft as an axis. Besides achieving reduction with mechanical precision, positive apposition is held during roentgenographic examination and the application of the plaster cast.

ROUTINE REDUCTION

Anesthetic of choice is given with the patient supine on a table or cart, with the shoulder *well over the table edge*. The new barbiturates administered intravenously can be successfully used for insertion of the half-pins and for placement in the splint, whereas the mechanical manipulations of reduction can be so smoothly performed that the little distress ensuing is generally controlled by an injection of morphine hypodermically. While developing the diagnostic roentgenograms,

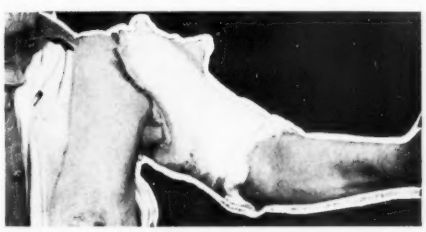


Fig. 1. Mr. W. M. with comminuted shaft fracture. For immobilization only a short cast to the upper arm is necessary, so that the elbow and shoulder joints are left free for immediate movements.

Read before the New York Academy of Medicine, New York, New York, March 20, 1936.

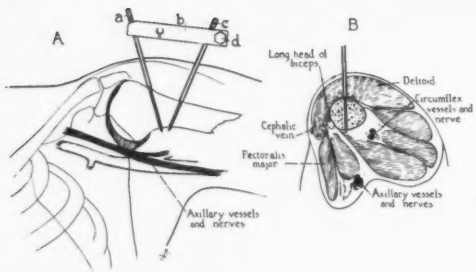


Fig. 2. A, Half-pin unit method of controlling upper fragment. Note distance between the joint capsule and the half-pins. Tuberosity half-pin, *a*, which is fastened to, but rotates in the clamping bar, *b;* fixation half-pin, *c;* fixation lock nut, *d*. Both the superior and distal units have been standardized and are made in 3 sizes—child, medium, and large. B, Cross section of left humerus just beyond acromial process with arm at right angles to the body. The half-pin is passed through the humerus from the center of the lateral aspect. Note the distance between the end of the half-pin and the brachial vessels.

Superior half-pin insertion. After the upper fragment has been located by probing with fine Kirschner wire, the upper or tuberosity half-pin is drilled in with the right hand, while the left hand holds the bar parallel to the arm. With the arm in 60 degrees of abduction, this half-pin is inserted through the skin at a point in the center of the lateral surface of the upper fragment just beyond the lateral edge of the acromial process; but with the latest technique, both superior half-pins are started about 1 inch anterior to the center of the lateral surface, and drilled in a medial and posterior direction so that the half-pins are never pointed toward the brachial vessels.

The fixation half-pin is next drilled in; but the cortex is usually so dense that it is advisable to resort to a hand or motor drill. After the half-pins have been drilled beyond the medial or opposite cortex the nut on the bar is firmly tightened.

Location and depth of half-pin insertions are then roentgenographically checked, with the direction of the roentgen-rays perpendicular to the half-pins. Sterility of the half-pin unit is maintained so that, if the fixation pin has penetrated the opposite cortex, it can be drilled in farther. However, if the tuberosity pin should be incompletely inserted, it is necessary to withdraw the fixation pin completely before attempting to drill the tuberosity half-pin in deeper.

the nerves and arteries are examined for evidence of trauma, after which the sides and superior surface of the shoulder and upper arm are surgically prepared. With the humerus in about 60 degrees of abduction the unsterile assistant exerts some manual traction on the forearm at the time the superior half-pins are inserted, as shown in Figure 7, A.

The tuberosities should first be accurately located by means of a Kirschner wire used as a probe. When placing half-pins, the operator should refrain from pushing too hard until the half-pin is well inserted (Figs. 2 and 7, A). The

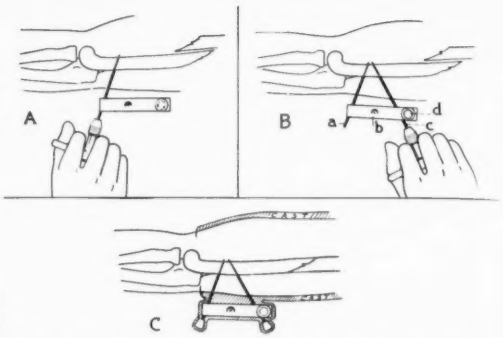


Fig. 3. A, Distal half-pin insertion. In the obese, the distal posterior humerus may be outlined by probing with a fine Kirschner wire before the first half-pin, *a*, fastened into the bar, *b*, though freely turning in it, is inserted through the skin at a point in the midline of the posterior surface of the arm at a level one finger's breadth superior to the epicondyles. This half-pin is also drilled in while the clamping bar is held parallel to the arm. B, The second or fixation half-pin, *c*, is next drilled in either by hand or with the aid of the hand drill, then locked in place by tightening the fixation lock nut, *d*. If in doubt, penetration of the distal half-pins may now be checked by fluoroscopic or roentgenographic examination. These half-pins should protrude beyond the anterior cortex, no harm being done if they protrude well beyond this border. Should the pins need to be inserted deeper, follow instructions as detailed for the superior half-pins. C, The half-pin unit is fastened to the distal horseshoe through medium of a short extension, after which reduction can be mechanically achieved and permanently held by firmly incorporating the unit in the cast, as represented.

hand or electric drill can be used to advantage here, as the pin can be rotated fast with only a little pressure exerted until the half-pin is well started. These half-pins are directed into the shaft in a slightly posterior direction so that if the pin accidentally slips off the bone on starting, it passes posterior to the humerus, thus missing the vessels.

Upon roentgenographic check of the depth of both upper half-pins, the entire lower arm and elbow are surgically prepared, whereupon the distal half-pins are inserted, as illustrated in Figures 3 and 7, B. If active extensor movements at the elbow are desired the distal half-pins are inserted with the elbow in full extension; and as soon as the arm is placed in the splint the elbow is immediately and completely flexed so that the triceps tendon and muscle are split around the half-pins. By this manipulation, the triceps muscle may later extend the forearm in the normal manner. However, if the distal half-pins are inserted in the humerus with the elbow in flexion the movement of extension at the elbow is then

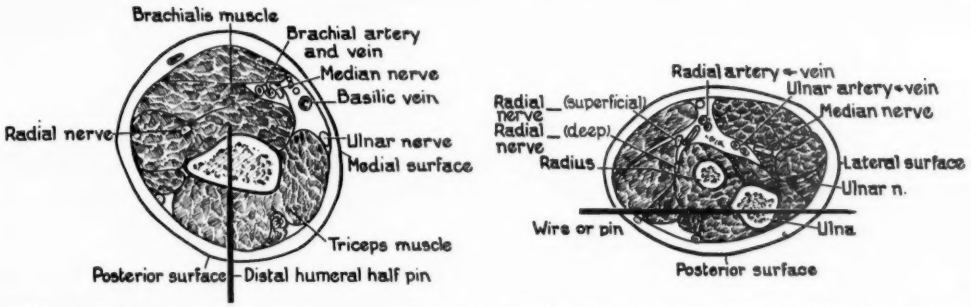


Fig. 4. Both cross sections illustrate practicality of transfixing either the lower humerus or the upper ulna, provided these bones are approached from their proper anatomical aspect. Left, above elbow; right, below elbow.

chiefly by the passive movement of gravity. Dry dressings are cut and placed around the pin wounds, with the adhesive tape against the dressings so as to prevent the patient fingering the pin wound. The dressings are held with a few turns of non-sterile sheetwadding, but no cotton bandages or adhesive tape should encircle the arm.

The table that supports the splint should be of such height that the center of the rotating arc is opposite the center of the shoulder joint. To facilitate this elevation and also roentgenographic examination we have devised a light adjustable stand, usually attached to the shoulder end of the apparatus (Fig. 7, C). The arm is then placed in the anatomic splint, both brackets are swung to the lateral side, with the arm in abduction, the elbow preferably in extension, and the distal fragment in a position midway between internal and external rotation.

Apposition is a mechanical achievement. When the roentgenograms reveal as nearly a perfect reduction as possible, a cast of the best plaster available—padded or unpadded—is applied from the acromial process to below the elbow, *securely incorporating both half-pin units* (Fig. 7, D). The arm is removed from the splint as soon as the plaster sets, whereupon the cast is cut out around the axilla and the elbow joint in order to permit free joint movements. The exposed ends of the half-pins and unit may then be plaster-covered.

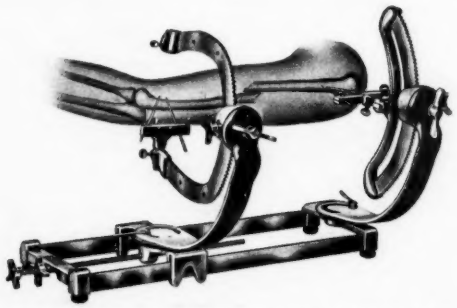


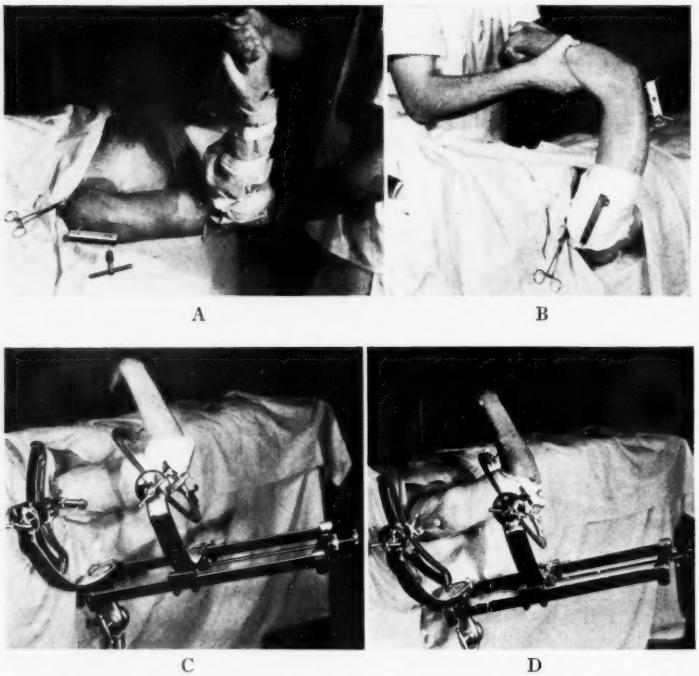
Fig. 5. The anatomic humerus splint fabricated from the anatomic leg splint by the attachment of a few accessories. The same splint may be used for the opposite arm by simply swinging the brackets to the other side, and may be employed for man, woman, or child by selecting the large, medium, or child size half-pin units. All movements at the shoulder, including abduction, adduction, anterior flexion, posterior extension, and rotation, are mechanically made at the glenoid fossa in the normal manner, while the distal fragment is manipulated with the center of the shaft as a center.

AFTER-CARE

The cast should be split and spread open over the brachial vessels at the first evidence of impairment of circulation, a procedure seldom indicated as immediate reduction and absolute immobilization minimize both swelling and shock.

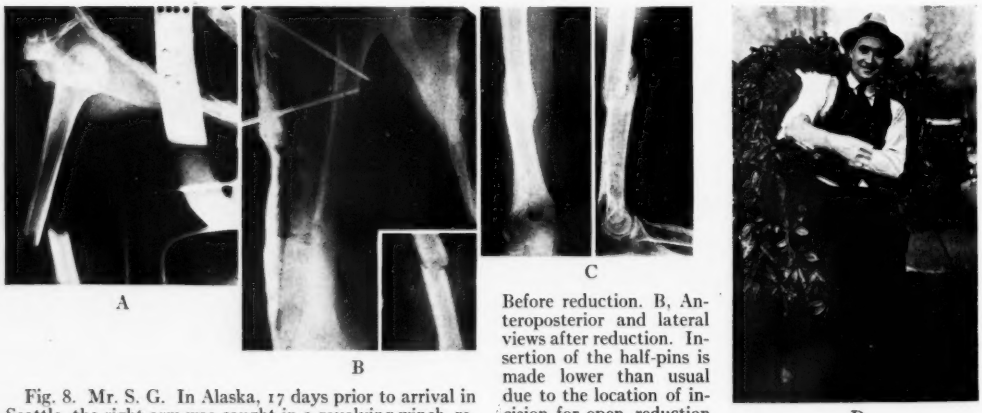
The fully dressed patient may leave the hospital on recovery from the anesthetic. If a sling is desired, it should be removed frequently, for the patient must be made to use the arm and move the joints. The arm and shoulder muscles should be both actively and passively exercised. The patient who is unaware of the presence of the pins should be instructed to keep fingers or sticks out of the cast.

Fig. 6. The sterile set-up. One basin with ether, the other with ¼ strength tincture of iodine. The drill may be used for the half-pins, or for a Kirschner wire if ulnar transfixion is desired.



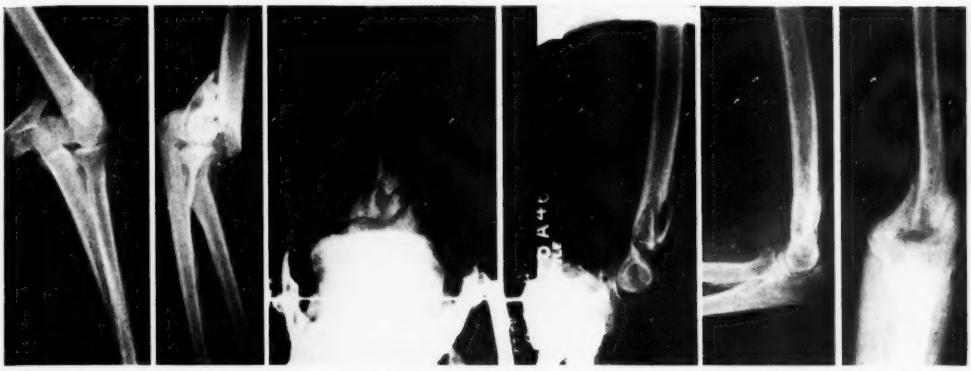
A B C D

Fig. 7. Steps in routine reduction, illustrated in the case of Mr. S. G., with fracture in middle one-third. A, Insertion of superior half-pins. B, Insertion of distal half-pins. C, Arm is placed in the splint, whereupon an attempt is made to obtain a perfect reduction with end-to-end contact. Fluoroscopic examination assists in achieving normal reposition but is used only to check position; no manipulation is done under fluoroscopic screen. D, Final reduction should be checked with films before plaster is applied.



A B C D

Fig. 8. Mr. S. G. In Alaska, 17 days prior to arrival in Seattle, the right arm was caught in a revolving winch, resulting in a fracture of the greater tuberosity, dislocation of the shoulder, fracture of the shaft, and paralysis of the radial, ulnar, and median nerves. Several unsuccessful attempts at reduction under anesthetic had previously been made. A, Before reduction. B, Anteroposterior and lateral views after reduction. Insertion of the half-pins is made lower than usual due to the location of incision for open reduction of shoulder dislocation. C, Final result. D, After cast was removed, patient fell and refractured shaft, which was again routinely reduced. The short arm cast permits maximum exposure for physiotherapy.



A B C D E F

Roentgenograms should be made a few days after reduction and repeated later to check apposition and callus formation. It is vital to obtain *and maintain end-to-end contact between fragments*, even at the expense of some overlapping. Separation from unequal drying of the plaster, or subsequent separation which might be due to late absorption of the fragment ends from circulatory trauma, can be adjusted by the removal of a thin transverse section of the cast, and the recementing of the plaster segments with a plaster bandage. This correction may be more readily repaired, first, by the replacement of the arm in the splint. A loose cast from recession of swelling calls for no correction, since it is not the tightness of the cast but the incorporated half-pins that maintain immobilization. In fact, an entire side of the cast is removable without affecting immobilization.

Movements of the arm at the elbow and shoulder joints not infrequently cause some pain due to the pull of the skin against the pins, which friction in turn induces a slight suppuration. This discharge, usually appearing from the second to the fourth week, is of itself no cause for concern as it is only an aseptic reaction from movement of the skin around the pins. If this irritation becomes too annoying, the arm should be kept quiet at the side with the forearm in a sling for a few days' rest. Poor technique, such as failure to transfix the humerus completely, or insecure incorporation of the half-pins, or the application of inferior plaster, may demand a second reduction.

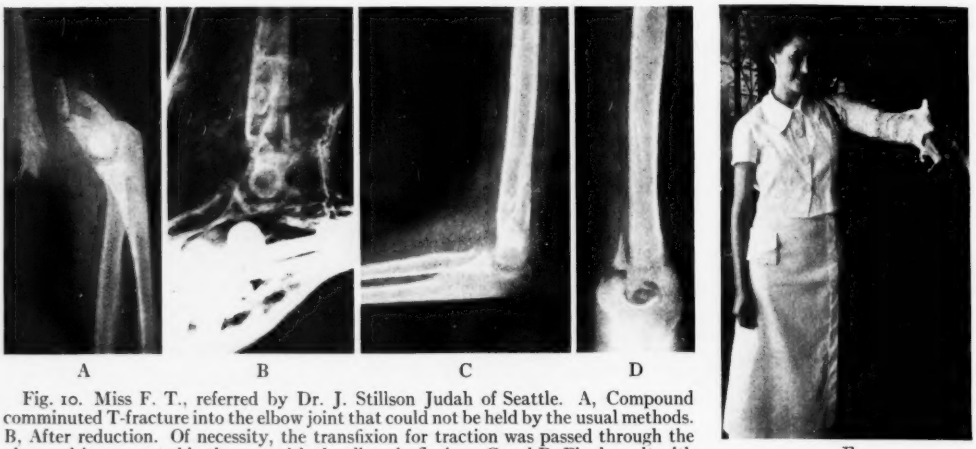
Fig. 9. Miss E. N., referred by Dr. W. I. Firey of Seattle. A and B, Roentgenograms of comminuted T-fracture into the elbow joint, before reduction. C and D, After reduction. Immobilization with Kirschner wire through ulna for traction. E and F, Final result a little over 4 months later. G, Illustrates movement of shoulder joint.

G

REMOVAL OF HALF-PINS

The fracture is immobilized for 6 to 9 weeks, or even longer, depending on callus formation. No attempt should be made to dress pin wounds during this time, even when there is a foul discharge from them.

The half-pins are removed by first uncovering the ends of the fixation half-pins and exposing their nuts. The cast and sheetwadding is then cut around the entire half-pin unit, the nut is unloosened and the fixation half-pin is withdrawn, after which this plaster island with the enmeshed half-pin unit is pulled out in the axis of the remaining half-pin. Green callus usually calls for some further protection, which is best provided in the form of a posterior molded plaster splint.



A B C D E

Fig. 10. Miss F. T., referred by Dr. J. Stillson Judah of Seattle. A, Compound comminuted T-fracture into the elbow joint that could not be held by the usual methods. B, After reduction. Of necessity, the transfixion for traction was passed through the ulna and incorporated in the cast with the elbow in flexion. C and D, Final result with 85 per cent elbow function. E, Immobilization with free shoulder movements.

COMMINUTED FRACTURES

For the comminuted fracture with one or more large loose central fragments, the cast should be snugly applied. Should the cast subsequently become loosened over these fragments from recession of swelling, a longitudinal section of the cast may be removed and the remaining cast circularly compressed. In other cases, the arm may be replaced in the splint and a longitudinal $\frac{3}{5}$ or even the whole cast removed and one that fits more snugly re-applied.

Occasionally it is advisable to make a large fenestration in the cast, into which a roll of sheet-wadding is fitted, so that it can be bandaged down snugly with a circular bandage until the fragment is replaced.

COMPOUND FRACTURES

Open wounds may be cared for by any standardized method: the wound may be débrided and primarily closed, or débrided and packed with Orr's vaseline gauze plus occluding cast; the arm with an open wound may be left exposed in the splint for several weeks for treatment by open air, maggot, or chemical lavage. If transfixion is done after débridement, a completely new sterile set-up should be used.

In cases of subsequent abscess formation or sequestration, the arm may be replaced in the splint and all or any portions of the plaster removed for required surgery—drainage, removal of sequestra, or such reconstructive steps as skin or other plastic operations. After the arm has been placed in the splint neither removal of the plaster cast nor moving patient to the x-ray or operating room interferes with apposition, for the splint securely holds reduction.

ALTERNATIVE METHODS

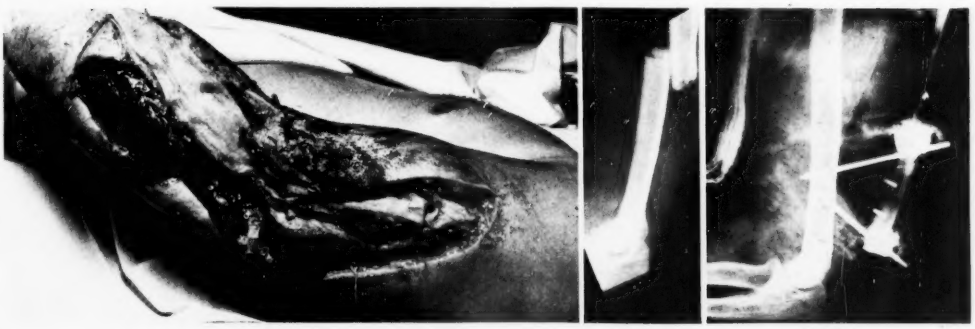
The distal transfixion can be placed in the ulna instead of the distal humerus (Figs. 4, 9, D, 9, G). In this event a wire or a $\frac{3}{32}$ inch pin is passed through the ulna, preferably at a point 3 fingers distal to the tip of the olecranon. With the elbow at right angles, the wire with its tautner, or the pin, is firmly incorporated in a segment of a cast prior to placement in the splint, this plaster cast extending from midforearm or midpalm up to about the fracture site. Although the distal bracket in this instance is swung from the side to the end position on the splint, nevertheless, all movements are made on the normal anatomical axis. Subsequent steps in reduction are similar to those of routine reduction.

ANOTHER FORM OF TRACTION

A means of obtaining traction without utilizing skeletal transfixion is through the agency of a snug cast from midpalm to about midarm with the elbow at right angles. After the plaster sets the elbow portion is fastened into the center of the distal horseshoe with a plaster bandage, after which reduction is carried out routinely.

SUPRACONDYLAR FRACTURES

Supracondylar fractures in children, irreducible by the usual methods, or in adults, the comminuted T-fractures extending into the elbow



A B C

D

Fig. 11. Mr. W. S., referred by Dr. Lester Steck of Chehalis, Washington. Automobile accident resulted in a fracture of the shaft with a small compound wound, and a large jagged laceration of the upper forearm. Prophylactic tetanus-gas gangrene antitoxin was injected immediately and the wound was débrided and closed 20 hours before I first saw patient. While removing sutures gas escaped under pressure so that the whole arm was laid wide open, thus necessitating enormous doses of mixed gas gangrene antitoxin to be given intramuscularly and intravenously, 92,000 units in the first 12 hours. Meanwhile, x-ray treatments were administered as advocated by Kelly and Faust. A, Appearance of wound on third day following operation. So much gangrenous muscle was resected that the upper end of the distal fragment persisted in protruding through the skin in spite of a body cast, so that on the twenty-sixth day after the accident, the half-pins were routinely inserted. B, Before reduction. C, After reduction. The distal half-pins were of necessity passed through the skin just adjacent to the wound edge. The slight separation between fragments was later corrected by removing a thin transverse section of the cast, as outlined in this article. D, Three days following the half-pin reduction, patient up and around. The plaster was extended to the hand for the sole purpose of promoting forearm soft tissue repair.

joint, are reducible and held with this technique, provided the distal transfixion is put through the ulna, as previously detailed.

FRACTURE OF THE NECK

The site of fractures of the neck precludes the use of the superior half-pins; therefore, for countertraction, a body cast is applied as far as the hip. This cast should be applied, when possible, without anesthetic, with the patient sitting on the edge of the table with the arm held in 75 degrees of abduction. The plaster extends down the arm for a distance of 3 to 5 inches.

When the plaster sets, the patient is placed supine on the table with the shoulder well over the edge of the table. A cast cutter is placed close by, and the anesthetic is given.

The distal half-pins are routinely inserted. Reduction may be obtained by manual traction on the forearm and by manipulating the half-pins, although better results are achieved by employing the apparatus. In this event, the arm stub of the cast is fastened with a plaster bandage to the center of the rotating arc when in the neutral or midway position, with the splint at an angle of about 75 degrees to the body cast. Here again the adjustable duraluminum floor stand assists materially in attaining quicker and better reduction, which can now be obtained with routine technique. Apposition is held by extending the cast down to the elbow in the form of a spica, incorporating the half-pin unit. The cast in the form of a plaster splint or a wooden splint is prolonged down on the under or ulnar side of the forearm, with the elbow at right angles. This acts as a support to the forearm; at the same time it makes no interference with elbow movements.

If desired, traction may be obtained by transfixing the ulna, in which event an arm cast incorporates this transfixion, applied from midpalm or midforearm to upper arm, with the elbow at right angles. The rotating arc is then attached to the arm stub of the body cast, as detailed above, but the elbow is placed in the splint, with the distal bracket in the end position instead of the usual side position. After reduction, the arm and body casts having been united in a spica cast, the splint is removed. Here again the patient treated in this manner is ambulatory on recovery from the anesthetic.

HUMERUS FRACTURE COMPLICATED BY FRACTURES OF THE FOREARM

With these multiple fractures, either the distal humeral or the ulnar transfixion acts in a dual capacity: first, as traction agent for the humerus fracture and, second, as countertraction agent for the forearm fractures. The humerus should be first reduced as detailed herein and the forearm managed as previously reported (1).

MALUNION OR NON-UNION OPERATIONS

The unsterile splint serves as an admirable fracture table for this type of surgery. Furthermore, as the apparatus consists of stainless steel and duraluminum, it can be sterilized by wrapping in a sheet and placing in the autoclave, to the end that all mechanical manipulations can be made with sterile gloved hands.

PRECAUTIONS

1. Locate the fragment by probing with fine Kirschner wire.
2. Insert the half-pins exactly as detailed.
3. Pierce the opposite cortex by the half-pins, as this is essential.
4. Avoid over-traction and maintain end-to-end contact, as this is imperative.
5. Take sufficient care—"Haste makes waste."
6. Aim to secure reduction that is roentgenographically perfect.
7. Apply carefully only the best grade of plaster.
8. Incorporate half-pin units securely in cast.
9. Remember the fracture committee warning —"It is not the splint but the doctor behind the splint that counts in the treatment of fractures."

SUMMARY

Humeral shaft fractures can be immediately reduced with practically perfect apposition if a specialized form of skeletal countertraction and skeletal traction is employed. Furthermore, this unique system effects complete immobilization, with only a short plaster encasement of the upper arm, both the shoulder and the elbow joints being left uncovered. Accordingly, from the freedom of joint movements and active arm and shoulder muscle exercises provided for, many physiological benefits ensue. It naturally follows that joint stiffness and muscle atrophy are prevented. With a patient fully dressed and the injured arm functioning at his side, many economic benefits are apparent. These advantages are evidenced in a relatively painless convalescence, little after care, and a minimum of hospitalization and expense.

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A RADICAL OPERATION FOR MALIGNANT TUMORS OF THE THYROID GLAND

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MALIGNANT epithelial tumors of the thyroid gland may be divided into 3 groups (3): (1) malignant adenomas, (2) papillary carcinomas and (3) scirrhous carcinomas. The relative incidence of these types of epithelial tumors in the Cleveland Clinic series of 289 malignant tumors of the thyroid gland is as follows:

Type	Per cent
Malignant adenoma	78.3
Papillary carcinoma	17.2
Scirrhous carcinoma	4.5

Since malignant adenomas and papillary carcinomas are the only types of thyroid malignancy that in our experience have been cured by surgery and since the malignant adenoma is nearly five times as common as the papillary carcinoma, it is clear that the malignant adenoma constitutes the bulk of the potentially curable thyroid malignancies. Inasmuch as it is usually impossible before operation to make an accurate diagnosis of the histological type of a thyroid tumor, malignancies of the thyroid should be treated in such a way as to afford the best chance for cure of the most common type. In other words, any malignant tumor of the thyroid should be dealt with as a malignant adenoma until proved otherwise.

In order to comprehend the principles of an operation for the removal of a malignant adenoma of the thyroid gland, a clear conception of the growth and dissemination of this type of tumor must be obtained. To quote from Graham (4), "It is to be understood that the tumors in the malignant adenoma group are considered to be carcinomas, and that the term malignant adenoma is used to designate a type of thyroid carcinoma. . . . In this group we find all grades of transition of the original adenoma into every supposed type and combination of carcinoma mentioned in the literature except pure papillary and pure scirrhous carcinomas."

The malignant adenoma arises from a pre-existing benign adenoma, at first remains within the capsule of the pre-existing adenoma, but later invades this capsule, infiltrates the surrounding thyroid tissue, and finally invades both the capsule of the thyroid and its blood vessels. The tumor tissue exhibits a striking tendency to invade venous channels, to grow in the veins, and to disseminate itself to the lungs and bones via the blood stream. Tumors of the malignant adenomatous type may show wide variations in the degree of anaplasia present, but invasion of the veins by tumor tissue is an almost constant finding and is, as Graham has shown, an excellent criterion of potential malignancy. Any tumor of the thyroid in which neoplastic tissue can be demonstrated within the lumen of the veins is potentially malignant and may already have metastasized via the blood stream. In addition, many tumors of this type show a marked tendency to form grossly visible tumor thrombi in blood vessels, and cases have been reported (5) in which the tumor has extended down the great veins of the neck and into the heart (Figs. 1 and 2).

Lymphatic dissemination of a malignant adenoma of the thyroid gland is relatively rare. It is possible that the paucity of lymphatics in the adenomatous tissue where the tumor originates is responsible for this failure of the tumor to metastasize to lymph glands. When such metastasis does occur, it is invariably in cases in which the tumor has broken through the capsule of the thyroid and has invaded the contiguous structures of the neck. When the disease has advanced to this stage and has invaded structures that cannot be removed, it is incurable. In short, metastasis to the lymph nodes does not occur until the tumor has broken through its capsule and invaded vital structures; for this reason, any operation which is designed to cure a malignant adenoma by resection of the cervical lymphatics is futile.

Long before the local invasiveness of the tumor has rendered it incurable, invasion of the blood vessels occurs. If distant metastasis has not occurred before operation and if the tumor has not extended through the capsule of the thyroid, wide excision of the tumor and its capsule and resection of the venous channels that drain the tumor give the best prospects of permanent cure. If the operation begins with resection of the internal jugular vein on the affected side (into which the superior and lateral thyroid veins drain) as well as a low ligation and resection of the inferior thy-

From the Cleveland Clinic.

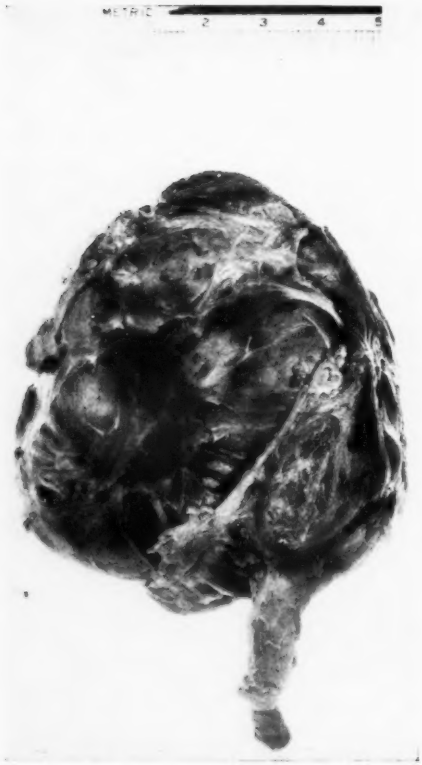

Fig. 1. Malignant adenoma of the thyroid gland with tumor tissue growing down the inferior thyroid vein. (Surgical specimen.)

roid vein, and if this is followed by a complete lobectomy, dissemination of the tumor by manipulation at operation will be avoided.

In a series of 49 cases of malignant adenomas, there were 20 local recurrences of the tumor. In 8 cases the recurrent tumor was excised and in 4 of these 8 cases the recurrence could be definitely demonstrated to be within the veins of the neck. Thus, in half the cases in which local recurrences were excised, the tumor was demonstrable in the veins of the neck.

The accompanying photomicrograph (Fig. 3) of a local recurrence of a malignant adenoma and the pathologist's description of the gross specimen indicate how clearly these recurrences can be shown to have taken place in venous channels. This patient is still alive and apparently free from cancer 7 years after excision of the recurrent tumor.

Examination of gross specimen. Specimen consists of a tumor mass removed from the left side of the neck, in the region of the left thyroid lobe, weight 10 grams. It measures 4 by 2.5 by 2 centimeters.

The external and anterior surfaces are covered by muscle, fascia, and fat. The mesial surface is made up in part by a wall of the large vein and by capsule of tumor tissue. The upper extremity of the mass consists of a cross section of a vein, 7 millimeters in diameter. This extends downward along the anterior and mesial surface of the mass for a distance of 3 centimeters. The whole segment of vein appears to be filled with a solid, pseudo-lobulated, firm, whitish tissue, containing very little colloid. The lower end of this segment of vein is relatively free from tumor thrombus and measures 8 millimeters in diameter. This segment of vein and its included tumor tissue make up the greater portion of the specimen.

Running obliquely from the anterior border downward and backward, across the mesial surface, there is another cord-like structure, varying from 3 to 7 millimeters in diameter. Examination of the anterior and upper end of the structure shows it to be definitely a blood vessel with the openings of branches into the lumen. Below this point, for a distance of 2 centimeters, this structure is occluded by tumor tissue.

Projecting from the inferior pole of the specimen, there is another vascular channel, probably filled with tumor tissue.

Along the inferior portion of the posterior border of the specimen is an apparently encapsulated nodule of tumor tissue, 1.5 centimeters in diameter. From the lower pole of this, there emerges a small, tubular structure, apparently a vein. *The dissection indicates that practically all the tumor tissue is confined within veins.* There is some question about perforation and local infiltration at the lower pole of the specimen.

It is probable that the main venous channel is a segment of the internal jugular vein. Other channels may be branches of the lateral thyroid veins.

Since resection of the venous channels draining the affected lobe of the thyroid eradicates the most common site of recurrences, it is clear that both distant metastasis and local recurrence of malignant adenomas of the thyroid should be diminished if the veins into which the tumor so frequently extends are resected along with the tumor mass.

TECHNIQUE

Since the possibility of carcinoma is occasionally suspected when carcinoma is not present, it is clear that the incision for exposure of a suspected thyroid carcinoma should be made in such a way as to leave an ordinary collar incision scar if carcinoma is not found. At the same time the incision should be placed in such a manner as to allow for its extension to give the wide exposure that is necessary for the radical operation if malignancy is encountered. The incision that most closely approaches this ideal is a high, wide, transverse incision made at the level of the cricoid cartilage.

After the skin incision is made the skin flaps are dissected upward and downward to enable the

Fig. 2. Photomicrograph of malignant adenoma growing in a vein (×95).

Fig. 3. Photomicrograph of malignant adenoma recurrent in veins of neck. (Surgical specimen.) (× 8)

operator to separate the pretracheal fascia and muscles in the midline and examine the thyroid gland. This examination is carried out gently and with care not to break the capsule of the gland. If it is evident that the tumor is malignant, the skin incision is extended vertically from the midpoint of the lower flap straight down to the suprasternal notch (Fig. 4). The skin flap including the subcutaneous fat is then dissected free of the platysma and deep cervical fascia on each side and is retracted. The pretracheal (sternothyroid, sternohyoid, and omohyoid) muscles are separated in the midline from the thyroid cartilage to the suprasternal notch. The muscles and cervical fascia on the side of the tumor are clamped and divided transversely as high as possible, so as to afford adequate exposure of the superior pole. At this level the sternomastoid is usually well lateral to the tumor and hence need not, as a rule, be divided.

The sternomastoid, the pretracheal muscles and the cervical fascia are again clamped and divided transversely, the line of section on this occasion being just above the insertion of the muscles into the sternum (Fig. 5). A careful attempt is then made to separate these muscles from the underlying capsule of the thyroid, and if they are not adherent, they are elevated like a trap door, and retracted laterally to expose the thyroid and the carotid sheath (Fig. 6). If the muscles are adherent to the capsule of the thyroid and their separation from the thyroid would entail risk of cutting into tumor tissue, it is better not to attempt this separation but to connect the lateral ends of the two transverse incisions by a vertical incision, expose the jugular vein by this means, and resect the overlying muscles along with the lobe of the thyroid.

Before any further manipulation of the tumor is attempted, the internal jugular vein should be isolated, doubly ligated, and severed low in the neck and again ligated and severed at a level just above the point of entry of the superior thyroid vein (Fig. 6). The inferior thyroid vein likewise should be ligated and severed as far as possible from the tumor. The inferior thyroid vein and the internal jugular vein with the superior and midline thyroid veins are then dissected out and are resected along with the entire affected lobe of the thyroid. In the course of the lobectomy, no attempt should be made to isolate or to preserve the recurrent laryngeal nerve. Such attempts result only in unnecessary manipulation with attendant liability to dissemination of the tumor.

Fig. 4. Lines of skin incision.

Fig. 5. Skin flaps elevated and muscles clamped preparatory to their division and reflection laterally.

The slight hoarseness that results from paralysis of one vocal cord is a negligible consideration as compared with the possibility of recurrence of the tumor.

It is usually advisable to ligate the arterial blood supply of the thyroid before liberating the gland from the trachea. The superior and inferior thyroid arteries are isolated, clamped, and divided well away from the gland in order to avoid manipulation of the tumor. The isthmus is then divided and the affected lobe is carefully dissected free from the trachea. It is best to make a sharp dissection at this point and to avoid placing clamps on the tumor even if slight oozing does occur. If the tumor has not extended through the capsule posteriorly, this procedure will allow the gland to be mobilized and from this point on it is easily removed.

During the course of the operation, the capsule is not broken by the insertion of hemostats or traction clamps, any desired rotation of the gland from its bed being obtained by inserting the finger behind the tumor and drawing it forward.

At the close of the operation the trachea and the carotid artery on the affected side are bare (Fig. 7). When there is extensive bilateral involvement, a condition which usually occurs only in advanced and incurable cases, the tumor is frequently fixed to the trachea and has invaded all contiguous structures. This type of tumor can rarely be removed completely and a radical operation is therefore not only dangerous but futile. In any case, bilateral ligation of the internal jugular veins should not be performed at the same operation.

Although this technique for the radical removal of a malignant adenoma of the thyroid gland is probably the most effective means of obtaining a permanent cure, unfortunately, only the minority of patients are seen early enough to permit complete excision of the tumor. When complete excision cannot be accomplished, it is still of value to ligate the jugular vein, excise as much of the tumor as possible, implant radon seeds in the remaining portions, and treat with deep roentgen-ray.

INDICATIONS FOR OPERATION

1. *Prophylaxis.* Over 90 per cent of all malignant tumors of the thyroid gland originate in preexisting adenomas (3). Therefore, in the vast majority of cases, prompt and complete removal of adenomas of the thyroid will protect the patient against the development of a malignant tumor.

It is impossible to determine by any clinical test the exact time at which a benign adenoma becomes malignant, but since nearly 1 per cent of all adenomatous goiters removed are found to contain malignant tumors that were not diagnosed before operation (2), the time to remove a discrete adenoma is as soon as the diagnosis is made. The risk in the removal of a simple adenoma is negligible, 1 fatality having occurred in our last 1,400 cases. On the other hand, the risk of leaving an undiagnosed cancer is considerable and, as has been shown, will occur approximately once in a hundred times if adenomas are not removed.

A distinction should be drawn at this point between the diffuse adenomatous goiter and the discrete adenoma of the thyroid. In the former,

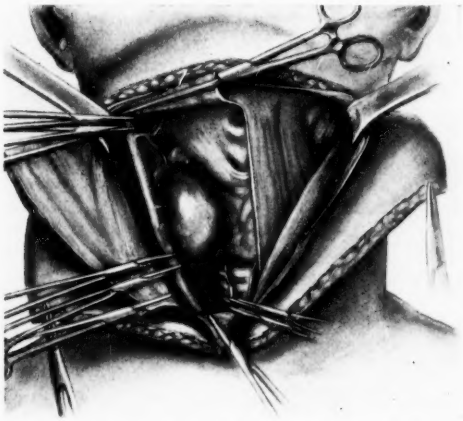

Fig. 6. Muscles reflected to expose tumor of thyroid gland. The internal jugular and inferior thyroid veins are doubly clamped preparatory to their division and resection.

Fig. 7. The entire lobe of the thyroid is removed. The ligated stumps of the internal jugular and inferior thyroid veins and the stump of the superior thyroid artery are seen. The carotid artery and the right side of the trachea are bare. (Note.—Although the recurrent nerve is not usually visible from this angle, its approximate course is indicated in this drawing.)

the entire gland is composed of many small nodules so that the pathological process is in reality an adenomatosis. Since the entire gland is involved, it is impossible to remove all the adenomatous tissue without removing all the thyroid tissue. If no particular area is of a different consistency from the rest, if no particular part of the gland is enlarging, if no hyperthyroidism, intrathoracic extension, or pressure symptoms are present, then the patient can be advised that thyroidectomy is not necessary provided she will agree to return for periodic observation.

On the other hand, if the goiter consists of a single, discrete adenoma or even of several discrete nodules which are of a consistency different from the remainder of the gland, and particularly if these adenomas are enlarging, then it is clear that something more than a generalized physiological process of degeneration and regeneration is taking place. In such cases there is a definite tendency to neoplasia in a certain circumscribed area of the gland and the adenoma should be cleanly excised. It is this type of adenoma which cannot be distinguished from an early malignant tumor.

2. *Indications for radical operation.* In patients over 40 years of age, a history of recent enlargement of a pre-existing goiter and the finding of a stony hard, uncalcified tumor in one lobe of the thyroid is indication for a radical excision of the affected lobe and its venous tributaries by the technique that has been described previously. Occasionally a calcified adenoma will prove confusing but such an adenoma rarely enlarges rapidly and can always be demonstrated by roentgen examination. Chronic thyroiditis is sometimes mistaken for malignancy but as a rule the tenderness of the gland, the pain on swallowing, and the relatively small size of the tumor mass will make the diagnosis clear. In any case it should be remembered that it is far safer, in view of the hopeless prognosis of incompletely removed cancers, to treat a suspected malignancy as a malignant tumor and perform the radical operation.

3. *Indications for palliative procedures.* Extensive bilateral involvement of the thyroid by a malignant tumor is usually associated with invasion of contiguous structures and indicates incurability. Likewise, paralysis of one or both vocal cords before operation shows extracapsular extension. There is no case in the Cleveland Clinic series in which a permanent cure has been obtained when laryngeal paralysis was present before operation.

Pain associated with a malignant tumor of the thyroid is likewise an unfavorable prognostic sign. No permanent cures resulted in a group of 7 patients who complained of pain. Pain does not, as a rule, occur until invasion of the capsule and cervical plexus has taken place. Similarly, fixation of the tumor signifies that extracapsular extension has taken place and that the disease is incurable.

In the presence of one or more of these signs or in the presence of demonstrable metastases in the

lungs or bones, a radical operation is futile. In these cases, we must rely on radiation therapy for palliation. It is nevertheless advisable to perform a biopsy to rule out the possibility of an atypical thyroiditis. When this is done, it is well to sever the preglandular muscles transversely so that the tumor may come forward, thus releasing the pressure on the trachea. Such a decompression will sometimes give symptomatic relief, but will not alter the course of the disease.

In some instances, the dyspnea incident to invasion or compression of the trachea by a carcinoma of the thyroid is sufficient to demand an immediate tracheotomy. The procedure is often technically difficult as a result of the necessity of making the opening below the site of compression or invasion. In addition, there may be a large mass of tumor tissue overlying the trachea, the resection of which results in troublesome bleeding. Tracheotomy is therefore a serious undertaking and in advanced cases the mortality rate from pneumonia is high, particularly when pulmonary metastases are present.

PROGNOSIS

The only two types of malignant tumor of the thyroid that are curable are fortunately the two most common—the malignant adenoma and the papillary carcinoma. In all other types, i.e., the scirrhous carcinoma, the lymphosarcoma, and the spindle cell sarcoma, there is little or no prospect of permanent cure by surgery.

1. *Prognosis in cases of malignant adenoma.* Forty-nine cases of malignant adenoma were selected for study. In all these cases, sufficient tissue for definite classification was available, the histories were complete, and the follow-up was complete to the time of the patient's death or to the fourth year after operation. Twenty-six per cent of these patients were alive and apparently free from cancer from 3 to 17 years after operation, an average cancer-free survival period of slightly over 7½ years.

At the end of 3 years, 43 per cent were alive, 2 per cent had died free from cancer, and 55 per cent had died from cancer. Deaths in the hospital following operation were included in this percentage.

At the end of 5 years, 35 per cent were alive, 2 per cent were alive at the last report but had been lost in the follow-up; 2 per cent had died of other causes and apparently were free from cancer, and 61 per cent had died from cancer.

At the end of 10 years, 68 per cent of the patients were dead from cancer, and at the end of 15 years, 70 per cent were known to be dead from cancer.

In the majority of the cases in this series, a course of radiation therapy was given after operation and in some instances this appeared to hold the disease in check. On the other hand, it is extremely difficult to evaluate the effects of roentgen therapy because of the great variability in the natural course of the disease. One patient, for example, to whom roentgen therapy was never given, is alive and apparently cancer-free more than 6 years after the original operation and more than 2 years after the excision of the second of two local recurrences in the veins of the neck. Had this patient been given roentgen therapy, her longevity might well have been ascribed to this treatment.

Excision of the veins of the neck was not performed routinely in this series of cases and sufficient time has not elapsed to allow any evaluation of the results of the radical operation. There are, however, 4 cases in which the internal jugular vein on the affected side was ligated or excised at the time of operation. In one of these, complete removal of the tumor was impossible, and the patient died within a month as a result of a local recurrence. The other 3 patients, in each of whom a section of the jugular vein was excised, all lived more than 9 years. Generalized metastases developed 8 years after the original operation in 1 patient; the second patient died apparently free from cancer 8½ years after operation; and the third is cancer-free 17 years after the original thyroidectomy. Although the numbers are too few to be of statistical value, the 75 per cent 5 year survival rate in this small group compares favorably with the 35 per cent 5 year survival rate of the group in which the veins were not excised.

Detailed studies of the group of 49 cases of malignant adenoma clearly indicate that the prognosis is dependent more on the extensiveness of the tumor and on the operator's ability to excise it completely than on the age of the patient, the duration of the recent enlargement of the goiter, the extent of microscopic invasion of blood vessels, or the degree of anaplasia of the tumor as based on histological grading.

Age. Fifty per cent of the patients under 45 years of age lived 3 years after operation, and 50 per cent of those over 55 lived 3 years after the operation.

Duration of enlargement of goiter. If the duration of the recent enlargement of a preexistent quiescent goiter is taken as a measure of the duration of the cancer before operation, it is found that the patients in whom the duration of the enlargement was the longest responded

better. Thirty-one per cent of the 16 patients who had first noticed enlargement of a pre-existing goiter or who had first noticed a goiter less than 4 months before entry were alive at the end of 3 years as compared to 55 per cent of the patients who had noticed enlargement of the goiter for more than 4 months. The explanation for this somewhat surprising finding is not clear, but it is possible that the invasive and incurable tumors give symptoms earlier as a result of extension to contiguous structures and hence impel the patient to seek aid earlier than do the non-invasive varieties.

Invasion of blood vessels. It was found that 55 per cent of the patients in whom microscopic examination showed extensive invasion of the blood vessels by tumor tissue were alive at the end of 2 years as compared with 40 per cent in whom lesser degrees of blood vessel invasion was demonstrable microscopically. The explanation for this surprising finding may be that the rapidly growing, invasive, and anaplastic tumors destroy the capsule and its vessels with such rapidity that blood vessel invasion is not easy to demonstrate, whereas the more slowly growing malignancies tend to grow in the lumen of veins without invading or destroying their walls.

In cases in which tumor thrombosis of veins was visible on *gross* examination, the prognosis was found to be somewhat worse than in the cases in which *gross* evidence of blood vessel invasion could not be detected. Gross invasion of the blood vessels is often associated with extension of the tumor thrombi into the veins of the neck, a condition which is incurable unless these veins are resected with the tumor.

Anaplasia and rate of growth. The tumors were graded histologically as to their degree of anaplasia and rate of growth, grade I being the slow growing and differentiated tumors and grade IV the anaplastic and rapidly growing tumors. It was found that in the patients who died in less than 2 years, the tumors were more anaplastic (average grade 2.33) than were the tumors in the patients who survived over 3 years (average grade 1.81). In spite of these findings, the correlation in this respect was not striking and a number of exceptions to the rule occurred. For example, 2 patients with grade IV carcinomas were alive at the end of 3 years and 4 with grade I carcinomas were dead at the end of 2 years. Thus, although there was found to be a definite relationship between the survival period of the patient and the degree of differentiation of the tumor, this correlation was not exceptionally striking nor entirely satisfactory in determining the prognosis.

TABLE I.—RELATIONSHIP OF COMPLETENESS OF EXCISION TO SURVIVAL AFTER OPERATION

	Patients alive 3 years after operation	Number of deaths in less than 3 years after operation
Incomplete excision	3	21
Complete excision	19	6

The completeness of excision of the tumor. By far the most reliable index of prognosis in this series was the completeness or the incompleteness of the excision of the tumor. In those cases in which the operative notes indicated that the tumor was completely excised, 76 per cent of the patients were alive at the end of 3 years whereas only 12.5 per cent of those in whom the excision was incomplete were alive at the end of this period. The outlook for the patient in whom the disease is in a sufficiently early stage that the tumor can be excised to the satisfaction of the surgeon is therefore six times as good as that of the patient in whom complete excision of the tumor is rendered impossible by its extensiveness or invasiveness (Table I). The impression of the surgeon as to whether or not he was able to remove the entire tumor is the most valuable single criterion for determining the prognosis in cases of malignant adenoma of the thyroid.

2. *Prognosis in cases of papillary carcinoma.* The papillary carcinoma of the thyroid gland arises in an adenoma, does not tend to invade blood vessels, and metastasizes late via the lymphatics. As a rule, however, no metastasis occurs until the capsule of the thyroid has been invaded and the tumor has become fixed to contiguous structures. Since metastasis does not occur until the tumor is locally incurable, radical excision of the lymph glands of the neck is futile.

The prognosis in this type of tumor is definitely better than in the malignant adenoma. Fourteen patients with the papillary carcinoma were followed for a period of 3 years or more after the operation or until death occurred. Twenty-one per cent of these patients died of cancer in from 1 to 3 years after operation. Two patients (14 per cent) died of causes other than cancer 30 months and 35 months, respectively, after operation, and the remainder (64 per cent) are alive from 3 years to 13 years after operation, an average survival period of slightly over 8 years. A clean excision of this type of tumor, therefore, gives excellent promise of a permanent cure. Moreover, since extension into the veins of the neck does not occur, resection of the veins is not necessary. Unfortunately, there is no certain way of differentiating

before operation between a malignant adenoma and a papillary carcinoma. Since the malignant adenoma is nearly five times as common as the papillary carcinoma, it is best to deal with all malignant tumors as if they were malignant adenomas and resect the veins of the neck along with the tumor.

CONCLUSIONS

1. The malignant adenoma is the most common malignant tumor of the thyroid gland.

2. The malignant adenoma and the papillary carcinoma are the only types of malignant tumor of the thyroid gland that, in our experience, have been cured by surgery.

3. Since the malignant adenoma is the most common type of thyroid malignancy and is nearly five times as common as the papillary carcinoma, any malignant tumor of the thyroid gland should be considered as a malignant adenoma until proved otherwise.

4. The malignant adenoma extends into, metastasizes through, and tends to recur in the veins of the neck.

5. A description is given of the technique of an operation that is designed to excise a malignant tumor of the thyroid gland and the veins that drain it.

6. Excision of the veins of the neck removes the zone into which malignant tumors of the thyroid gland most commonly extend and recur, and is comparable to axillary dissection in carcinoma of the breast.

7. The prognosis in malignant adenoma and papillary carcinoma is fairly good if complete excision can be accomplished. The prognosis was excellent in a small group of cases in which the jugular vein was excised with the tumor.

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ECTOPIC KIDNEY

A Review of 97 Cases

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ECTOPIC literally means "out of place." By definition an ectopic kidney is one that owes its position to developmental failure; it has been arrested in ascent during embryonic life and usually has failed to rotate.

Braasch (3) described the ectopic kidney as one below the level of the second or third lumbar vertebra, and he pointed out that it may be difficult when the kidney is above the level of the iliac crest to distinguish ectopic kidney from acquired renal ptosis. The pelvis of an ectopic kidney is usually anterior and bizarre in outline. The calyces may extend anteriorly, medially, or laterally, and often there is a tendency to duplication. The ureter of the ectopic kidney is always short.

EMBRYOLOGY OF THE KIDNEY

Huntington and Pohlman have each given a clear-cut and readily understandable explanation of the embryology of the kidney. From their descriptions it seems that the kidneys appear first in the 5 millimeter human embryo as two buds which are placed close together in front of the second sacral segment. These buds arise from the wolffian duct a short distance from its entrance into the cloaca and sprout just before the 10 millimeter stage is reached, giving rise to the primary branches which result in the primary calyces.

The kidneys migrate upward, following the line of the degenerating mesonephros, and axial rotation occurs at the midlumbar level in the 14 millimeter embryo. The kidneys acquire their permanent blood supply when the normal position is reached in human embryos of 25 to 30 millimeters, or at the end of the second month. In the course of the kidney's ascent its blood supply is derived from several temporary sources, any of which may become permanent renal vessels should ascent be arrested.

In all but exceptional cases the ectopic kidney, aside from its position, is comparatively normal and contains the same amount of cortex as the normal opposite kidney. In rare instances the anomalous development affects the cortical portion of the kidney as well as the calyces and pelvis, resulting in congenital hypoplasia and sometimes, although rarely, agenesia. As a general rule axial rotation does not occur in ectopic kidney, and the pelvis remains anterior to the calyces, which produces a bizarre urographic picture that might by the unexperienced eye be misinterpreted and lead to an erroneous diagnosis of renal neoplasm.

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INCIDENCE

Campbell reported the incidence of ectopic kidney at necropsy as 1 in 660 individuals. Thomas and Barton, in 1936, reported 22 cases in 22,000 necropsies performed at the University of Minnesota, or an incidence of 1 in 1,000; in their series 7 were pelvic kidneys, 3 lying across the brim of the pelvis proper and the remainder lying in the lower iliac fossa. Thomas and Barton reported clinical incidence of ectopic kidney as 1 in 547 urologic examinations.

In reviewing the records of all cases of ectopic kidney encountered at The Mayo Clinic up to February 1, 1936, we were able to find a series of 97 cases. Nine of these cases were encountered in the course of approximately 11,000 necropsies (or about 1 in each 1,200 necropsies); the remaining 88 were seen clinically. In 52 of these 88 cases the diagnosis was established during the course of urologic examination, including pyelographic study; whereas in the other 36, the diagnosis was made at the time of surgical exploration. These 88 clinical cases of ectopic kidney represent an incidence of about 1 in every 10,000 patients examined or treated at the clinic.

Included in this series of 97 cases are 3 previously reported by Braasch (2) and 19 previously described by Judd and Harrington. We have included them in order to make the report complete.

The discrepancy between the incidence at necropsy and that at clinical examination suggests that many ectopic kidneys do not cause symptoms, hence special examinations were not done and they went undiagnosed.

Forty-seven of the patients were males and 50, females. At the time the diagnosis was made 5 patients were in the second decade of life, 27 in the third decade, 21 in the fourth, 24 in the fifth, 12 in the sixth, 7 in the seventh, and 1 in the eighth.

Fig. 1. Pyelogram of a left ectopic kidney located in the pelvis, showing the short ureter and bizarre arrangement of the calyces.

Fig. 2. Pyelogram of a right ectopic kidney opposite the crest of the ilium. The renal pelvis is anterior and the calyces are directed mesially.

LOCATION OF THE ECTOPIC KIDNEY

In the 88 clinical cases there was no great disproportion in location of the anomalous kidney as regards the left or right sides. It occurred on the left side 40 times, on the right side 46 times; in the 2 remaining cases there was bilateral ectopy. In the small series of cases at necropsy there was more disproportion, the left being the site of the anomaly five times and the right twice, the 2 remaining patients having fused kidneys.

In describing the location of the ectopic kidney we have employed three terms, "pelvic," "iliac," and "abdominal." By "pelvic" we mean a kidney that is located in the true pelvis (Figs. 1 and 7), by "iliac" one that is found either in the iliac fossa or opposite the crest of the ilium (Fig. 2), and by "abdominal" one that is fixed either below the level of the second or third lumbar vertebra and above the crest of the ilium (Fig. 3), or one fixed far laterally in the abdomen (Figs. 4 and 5).

In the series of 88 clinical cases there were 56 examples of pelvic kidney, 7 of iliac kidney, and 25 of abdominal kidney, whereas in the series of 9 necropsy cases there were 5 examples of pelvic kidney, 2 of which were bilateral, forming the so called shield or cake kidney; (Figs. 6 and 7), 1 of iliac kidney, and 3 of abdominal kidney.

STATUS OF THE OPPOSITE KIDNEY

The opposite kidney was normal as far as any developmental anomaly was concerned in 81 cases; it was congenitally absent in 8 cases and abnormal in 8.

The anomalies found in the opposite kidney in the 8 cases were as follows: fetal lobulation in 1 case, duplication of the renal pelvis in 1, incomplete rotation in 2, and bilateral ectopy in 4 cases. Two of these cases in which bilateral ectopy was present were observed clinically, whereas the other 2 were found at postmortem examination, the death of the patients having had no relation to the anomalous renal condition.

SOLITARY ECTOPIC KIDNEY

Congenital absence of the kidney opposite the ectopic kidney, as was previously stated, was noted in 8 cases. The fate of this opposite kidney during embryonic life provides an interesting though hardly profitable subject for speculation.

Treatment in such cases was of necessity conservative, and at this point it is well to stress the importance of proving the existence and good function of the opposite kidney before any treatment of an ectopic kidney is begun, especially if nephrectomy is contemplated. In a fair proportion of cases the diagnosis of ectopic kidney will be made during surgical exploration for a supposed

pelvic or abdominal tumor. In such event the ectopic organ must be treated conservatively, if at all, unless during exploration the surgeon can satisfy himself that a normally functioning opposite kidney is present.

BILATERAL ECTOPIC KIDNEY

True bilateral ectopy of the kidney is indeed rare, and many alleged examples are in reality unilateral fused kidneys. In our opinion, in cases of unilateral fused kidney one kidney is in a position which cannot be considered abnormal, hence the condition is really not one of bilateral ectopy.

McCown, in 1929, collected 24 cases of bilateral renal ectopia from the literature and added 2 of his own, which made a total of 26. Coppridge, in 1934, reviewed the literature and found 21 cases of bilateral pelvic kidney; he added 1 case of his own, which made a total of 22 cases. In the present series we encountered 2 clinical cases and 2 postmortem cases of bilateral ectopia, and we think that 1 of the clinical cases is of sufficient interest to justify a brief review of the history:

The patient in this case was a white, married man, 48 years of age, who came to the clinic on May 13, 1935. His chief complaint was pain in the left side of the abdomen which had begun following mild trauma to the lower part of the abdomen 10 years previously. This pain had been intermittent in type and had occasionally been projected into the medial aspect of the left thigh and leg; it was accompanied by a desire to defecate, urinate, and vomit. There had been no chills or fever. The excretory urogram showed the left renal pelvis to be opposite the third, fourth, and fifth lumbar vertebræ and adjacent to the spinal column and overlying the transverse process of the first sacral vertebra. There was a stone, 2 centimeters in diameter, at the ureteropelvic juncture causing marked pyelectasis (Fig. 8, a). The right kidney was not visualized in the intravenous urogram. A retrograde pyelogram showed the right renal pelvis to be located over the midportion of the sacrum just to the right of the midline, and it was dilated grade 1+ (Fig. 8, b). Specimens of urine obtained from each kidney contained no pus, nor were organisms grown on culture of the urine. Left pyelolithotomy was performed through a left inguinal incision. There was no evidence of fusion of the kidneys. Convalescence was uneventful.

ASSOCIATED ANOMALIES OF OTHER ORGANS

Guizzetti stated that anomalies of the genitalia are present in a third of the cases of renal anomaly. Tolson and Adams and others reported variations in the female pelvic organs in association with ectopic kidneys. Looney and Dodd described a case of ectopic kidney in which the jejunum, ileum, and ascending and transverse colons were found to be suspended by a common mesentery; the root of this mesentery was attached for 2 inches (5 centimeters) around the superior

Fig. 3. Retrograde pyelogram of a right ectopic kidney in fixed position just lateral to the third and fourth lumbar vertebræ. The ureter is inserted laterad to the calyces, which are directed mesially.

mesenteric artery. The testis was lodged against the kidney and the right inguinal canal contained the processus vaginalis, extending from the right inguinal ring to the bottom of the scrotum. Below the external ring the vaginal process was obliterated, whereas that portion within the canal was patent and contained a small peritoneal sac. Peterman, in examining at necropsy an infant 8 months old who had an ectopic right kidney, found absence of the spleen and left kidney, although the left suprarenal gland was in its normal position. The stomach was fetal in type, tubular, and had a capacity of about 60 cubic centimeters.

These are merely examples, however, and no attempt has been made by us to collect and describe all of the anomalies that have been recorded in the literature in association with ectopic kidney. In the present series of cases anomalies elsewhere in the body were encountered in 1 necropsy case and in 12 of the clinical cases.

The anomalies found in the cases of 9 women were as follows: absence of the vagina in 1 case, congenital small vagina in 1, infantile external genitalia in 1, complete absence of the uterus,

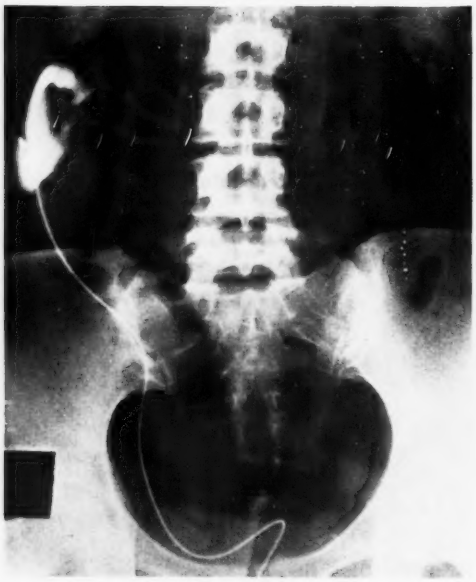

Fig. 4. Retrograde pyelogram showing an ectopic solitary kidney fixed in the abdomen far lateral to and below its normal position; the lower calyces are very short. The left kidney was proved absent by cystoscopy and intravenous urography.

Fig. 5. Intravenous urogram showing an abdominal type of ectopic kidney. The pelvis lies anterior to the calyces, although accentuation of the media contained in them makes the calyces seem anterior.

oviducts, and ovaries in 1, absence of the body of the uterus and a rudimentary horn on the left in 1, bicornate uterus in 1, absence of the right broad ligament and right oviduct and ovary in 1, congenital malformation of the pelvic organs of an unspecified type in 1, and congenital malposition of the right suprarenal gland (which was adherent to the liver) in 1.

The anomalies found in the cases of 4 men were as follows: absence of the frontal sinus in 1 case, undescended right testis in 1, congenital malformation of the liver and duodenum in 1, and transposition of the sigmoid and descending colon in 1.

It is quite probable that various other anomalies existed which were not noted during the course of examination and treatment; however, we have listed all those which were noted on careful study of the records.

SYMPTOMS

An ectopic kidney may become the seat of the same diseases to which a normally placed kidney is subject. In many of the cases in this series there were apparently no urologic symptoms. Ten patients suffered dysuria, frequency, or hematuria, but such symptoms certainly were not related to the anomaly; rather they were due to intercurrent infection or calculus. Twenty-nine of the patients gave a history of pain, and only 5 others were conscious of a tumor.

The fact that 29, or 32.9 per cent, of the 88 patients observed clinically suffered from recurrent attacks of pain is evidence that drainage from an ectopic kidney is often incomplete. This may result from the fact that free drainage of urine through the ureteropelvic juncture is prevented by anomalous blood vessels or constricting bands of capsular or peripelvic tissue. In most cases the pain complained of was not projected to the lumbar region in the fashion usually noted when a diseased kidney is in normal position. This is of course not strange since, for instance, an ectopic pelvic kidney could hardly be expected to cause pain high in the lumbar region. In the majority of cases, therefore, the pain was of an atypical or bizarre nature and its projection was as a rule peculiar. One patient, a boxer by profession, who had a pelvic kidney which functioned normally, thought he noted an indescribable sensation develop low in his abdomen whenever he skipped

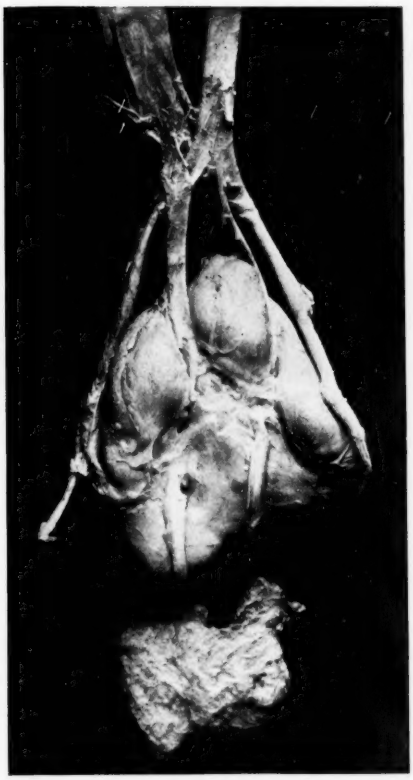

Fig. 6. Bilateral ectopic kidneys which were fused to form a "shield" or "cake" kidney that lay in the pelvis between the iliac vessels.

the rope during the course of his pugilistic training. His great success at his chosen calling, however, definitely disproved any disability from the renal anomaly.

TREATMENT

In the majority of cases in this series there seemed to be no indication for treatment of any kind, for the ectopic kidney was functioning normally and as far as could be determined was not a detriment to the patient's health. In a few cases an existing pyelonephritis was treated in the usual manner. In the absence of a degree of disability which justified surgical exploration, treatment other than for infection was rarely attempted.

Theoretically it should be possible with bougies or bulbs passed through the cystoscope to dilate the ureter and thus improve drainage and relieve

Fig. 7. Fused bilateral ectopic kidneys lying below the iliac vessels.

mild pains which possibly originate in an ectopic kidney, but as a matter of actual practice greater harm than good generally results from such efforts. In an occasional case a ureteral catheter was passed and was left in place for a number of days, apparently with benefit for mild pain disappeared. It is possible, however, that the improvement was of psychic origin.

Twenty-one surgical procedures were performed on ectopic kidneys in this series, 17 of which were nephrectomies and 4 pyeliolithotomies. It will be recalled that the diagnosis of ectopic kidney was established at the time of surgical exploration in 36 cases. In several of these cases exploratory operation was performed to determine the nature of an abdominal or pelvic tumor; the existence of an ectopic kidney was entirely unsuspected and pre-operative pyelograms had not been made. In view of the fact that the kidney was normal except for its anomalous location, nephrectomy was therefore deemed unnecessary.

In several other cases gynecological or other abdominal conditions were the primary reasons for operation, and the ectopic kidney, with its congenital anomalous blood supply, fixed position, and short ureter, was noted as an incidental finding. It is of course necessary to distinguish such kidneys from the ordinary low-lying kidney which is regarded as true renal ptosis. The latter type of kidneys are freely movable, have a normal

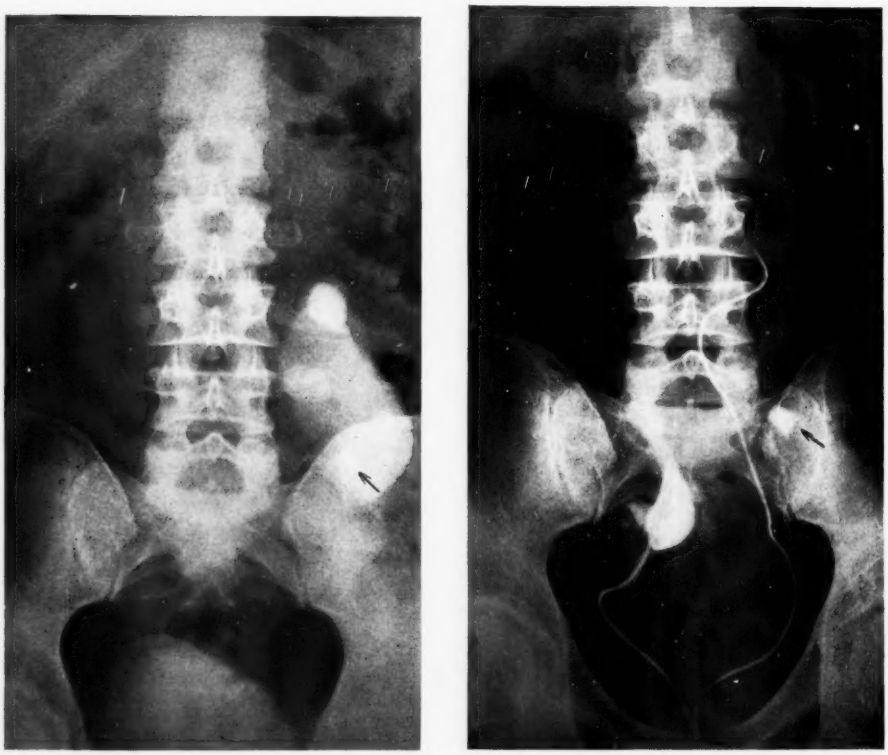

Fig. 8, a, left. Intravenous urogram showing marked hydronephrosis in a left ectopic kidney containing a stone (the stone is better visualized in the pyelogram to the right). b, Retrograde pyelogram of a right ectopic pelvic kidney, showing a stone overlying the left side of the sacrum just laterad to the lead catheter.

blood supply, and can be readily restored to their position in the renal fossa. We have carefully excluded all such cases from our series.

One patient presented himself with a urinary fistula draining in the left groin. This had followed operation, elsewhere, at which time a portion of a tumor had been excised and drainage instituted. It was evident that the lesion was a hydronephrotic ectopic kidney and complete nephrectomy eliminated the complaint.

Nephrectomy was performed in another case for a hypernephroma, weighing 2200 grams, in a pelvic ectopic kidney. Prior to operation the lesion had been thought to be an ovarian tumor. Recovery was uneventful.

In 2 cases the ectopic kidney was the seat of tuberculous infection and nephrectomy was followed by complete recovery from a previously intractable cystitis. It seemed to the surgeon at the time of exploration in 5 cases that the ectopic kidney was more or less atrophied, and that this probably accounted for the symptoms of which the patient complained; hence nephrectomy was performed.

Hydronephrosis combined with either infection or stone was the reason for nephrectomy in 8 other cases. One might think that some variety of plastic operation on the distended renal pelvis might be considered, or that ligation of a blood vessel or division of a band of tissue causing obstruction might effect a cure. As a matter of fact, however, these procedures are unwise, and simple removal of a stone, if it is present and renal function is good, or nephrectomy, if the condition of the opposite kidney permits, seem definitely better forms of surgical treatment. In 1 of the cases in this series ligation of a blood vessel had no effect whatever on the patient's symptoms, even though

drainage from the kidney was definitely improved as a result of the operation; several months later nephrectomy was performed, with complete relief.

It was necessary in 1 case to perform permanent nephrostomy because the opposite kidney had insufficient function to sustain life.

PATHOLOGICAL FINDINGS

An attempt was made to study the frequency of infection of urine from ectopic kidneys as well as the presence of hydronephrosis, pyonephrosis, and stone. We did not consider the kidney infected unless urine containing pus and bacteria was obtained by ureteral catheterization, whereas evidence of hydronephrosis and stone was obtained from examination of the kidney removed by, or examined at, operation or from pyelographic examination. It was found in the clinical cases that there were 20 ectopic kidneys showing some degree of infection; the 68 remaining did not. In 15 cases there was evidence of hydronephrosis in addition to infection (Fig. 9), in 5 cases stones were present as well as infection, and in 2 cases a stone was present, apparently without infection being present (Figs. 10, a and b, and 11).

Tuberculosis of the ectopic kidney was diagnosed in 2 cases, but there was no reason to think that the renal anomaly contributed in any way toward development of the disease. That an ectopic kidney may be subject to formation of a tumor is proved by the 1 case in which a large hypernephroma occurred in a kidney situated in the pelvis.

There was no evidence in this series of cases that the ectopic kidney is any more liable to

Fig. 9. Intravenous urogram showing hydronephrosis in a left ectopic kidney situated in the pelvis, and showing the deformity of the bladder, apparently caused by pressure of the adjacent kidney.

Fig. 10, a, left. Plain roentgenogram showing a stone (see retrograde pyelogram on right). b, Retrograde pyelogram of a right ectopic pelvic kidney, showing the stone in the upper group of calyces.

Fig. 11. Left ectopic kidney containing a stone and overlying the sacro-iliac joint; the stone appears as a filling defect in the renal pelvis.

damage in the ordinary course of life than is a normally placed kidney. A possible exception to this is when pregnancy occurs in a case of ectopic pelvic kidney.

PREGNANCY AND ECTOPIC PELVIC KIDNEY

From time to time one sees in the literature the statement that a pelvic kidney may be the source of dystocia. Cragin, as early as 1898, reported 5 cases that had been discovered during labor and felt that such a kidney was able to produce extreme dystocia. He suggested that it was an indication for the induction of early labor or for cesarean section.

In this series of 97 cases there were 23 married women with pelvic ectopic kidneys. Two of them had never been pregnant; but of the 21 women who had conceived, 14 had had one or more children without difficulty (Figs. 12, a and 12, b), and 5 had had one or more miscarriages with no full-term pregnancy. Another woman in the group had a full-term pregnancy, which resulted, however, in a dead child as a result of instrumental delivery. The remaining patient who had been pregnant said that her first child had been delivered with instruments, but that the next 2 pregnancies had required cesarean section. It is therefore evident that in the majority of cases labor will progress normally in spite of an ectopic pelvic kidney, and the mere existence of the anomaly does not warrant radical measures either

Fig. 12, a, left. Left ectopic pelvic kidney, showing tendency toward duplication of the renal pelvis; this woman had given birth to 4 children, labor apparently having been normal. b, In this roentgenogram of the right kidney, there is shown definite duplication of the pelvis and some elongation.

in regard to the misplaced kidney or the developing fetus. The necessity of cesarean section can probably be determined in advance of labor by an examination which includes careful internal pelvic measurements made in the usual manner.

SUMMARY AND CONCLUSIONS

In a series of 97 cases of ectopic kidney the condition was discovered at necropsy in 9 cases, and by physical examination or surgical exploration in the 88 remaining. This is an incidence of about 1 in every 1,200 necropsies performed at the Mayo Clinic and represents an incidence of approximately 1 in every 10,000 patients observed clinically.

Because of lack of symptoms which might lead to urologic investigation renal ectopia is often discovered only at the time of surgical exploration; in 8 cases of our series the ectopic kidney was a congenital solitary organ. which fact must be carefully weighed if anyone contemplates nephrectomy in cases of renal ectopia without the advantage of pre-operative urographic study.

Twenty-nine, or 32.9 per cent, of our series of 88 patients clinically found to have ectopic kidney suffered from recurrent pain, indicating that the ectopic kidney as a rule drains poorly owing either to its position or to constriction of the ureteropelvic juncture by anomalous blood vessels or perirenal tissues.

Treatment, such as ureteral dilatation, may cause harm and generally will not benefit the patient. As a general rule if treatment is indicated, it should be surgical in type. Conservative operations, such as plastic procedures on the renal pelvis or ligation of anomalous vessels, are likely to fail. Nephrectomy is therefore the treatment of choice if the function of the opposite kidney will permit. The only exception is pelviolithotomy in cases in which there is little or no hydronephrosis.

Pregnancy will generally be uneventful and labor normal in spite of an ectopic pelvic kidney.

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SARCOMA OF THE RENAL HILUS

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SARCOMA of the kidney excluding Wilm's tumor or embryonic tumors occurring in children is of such rare occurrence that individual cases when encountered are reported, and sarcoma originating from the renal pelvis or hilus continues to remain a curiosity. Since sarcomas are mesenchymatous in origin, they may originate from the renal capsule, the interstitial tissue, the blood vessels of the renal parenchyma, the pelvis, and the renal hilus. The tumors, frequently, are of such large size that their origin is very difficult to establish. Boyd states that sarcoma of the kidney always arises in the capsule and secondarily invades the renal parenchyma. Koehler describes a case of liposarcoma originating from the fatty capsule of the upper pole of the kidney.

A variety of sarcomas situated in the parenchyma of the kidney have been described: leiomyosarcoma by Delaney, reticular cell sarcoma by Elmer and Boylan, osteoblastoma by Haining and Poole, fibromyxosarcoma by Nichols, fibrosarcoma associated with stones by Kretschmer (9), etc. In this group, the tumors originated from the interstitial mesenchyma. The existence of primary lymphosarcoma of the kidney is questionable, although the kidney is a favorite site of metastasis. Some writers believe that the renal pelvis may also give rise to sarcoma, and such cases have been reported by Kretschmer and Randolph (8), Watson and Russum, and Lynch and Thompson.

The tissues found in the renal hilus may be the source for a variety of tumors which must be distinguished from tumors of the renal parenchyma, the pelvis, the adrenals, and retroperitoneal tissues. Tumors originating at the renal hilus compress the blood vessels of the kidney, the ureter, and also compress and displace the kidney. De Vecchi and Solomon reported a peculiar form of sarcoma of the renal hilus and pelvic tissue. The tumor was bilateral, occurred in infants under 2 years of age, and encircled the ureter, great vessels, pelvis, and papillæ, but was demarcated from the renal parenchyma. Histologically, the tumor consisted of round cells and spindle cells.

Myxoma and myxosarcoma of the renal hilus produce bulky masses, infiltrate the surrounding tissues, and cause displacement, stretching, and atrophy of the kidney (5). Benign tumors of the renal hilus noted are lipoma, myoma, and angiolipoma.

Sarcomas originating in the region of the renal hilus are very apt to be mistaken for tumors of the renal pelvis. Upon closer inspection of the gross specimen, and from histological studies, it may be noted that in this type of tumor the pelvis is usually not involved, but just compressed and displaced by the tumor mass.

The etiology of sarcoma of the renal hilus is unknown. In the group of sarcomas originating from the parenchyma of the kidney associated with renal stones, it is possible that the stones may initiate chronic inflammatory changes with subsequent sarcomatous degeneration.

In a review of 42,450 surgical specimens from July, 1928, to July, 1936, inclusive, 36 malignant tumors of the kidney were encountered.

They are as follows: Fibrosarcoma of the hilus, 2; carcinoma of the pelvis, 2; hypernephroid carcinoma, 30; and Wilm's tumor, 2. Thus the incidence of sarcoma in this group was 5.55 per cent of the malignant tumors of the kidney. During this same period 38 malignant renal tumors were encountered in a series of 8,732 consecutive autopsies at the Cook County Hospital. In this group there was 1 sarcoma, an incidence of 2.6 per cent. The tumor was found in the renal cortex as an incidental finding in a white male, aged 63 years; the cause of death being hypertensive heart disease. Histologically, the tumor was a fibrosarcoma.

CASE REPORTS

CASE 1. A white male, aged 59 years, entered the medical service of the Cook County Hospital in January, 1935. He had been in good health until 4 years ago when he became short of breath, developed edema of his ankles, and had to be hospitalized for 3 weeks. For the next 3 years he was free of symptoms except for fainting spells which would occur about once a month. Three months prior to his admission, shortness of breath occurred associated with orthopnea and swelling of his legs. He stated that for many years he experienced pain in his back without relief. During the past 6 months he had lost 15 pounds in weight. Lately he had developed nocturia, three to four times a night, frequency during the day, six to seven times, and painful urination.

The past history disclosed that the patient had a tumor removed from the left side of his back in 1932 at another hospital. The nature of this tumor could not be ascertained.

From the Department of Surgical Pathology, Dr. R. H. Jaffe, Director, and the Department of Urology, Cook County Hospital, Chicago.

Fig. 1. Case 1. Roentgenogram shows the tumor mass *T*, in the right upper quadrant displacing the pelvis and the superior calyx of the kidney downward.

Physical examination revealed a fairly well nourished white male, who appeared dyspneic. His blood pressure was 140 systolic and 70 diastolic. His temperature was 96.6 degrees; pulse, 108; and respirations, 28. The lungs disclosed roughened breath sounds. The heart was slightly enlarged to the left, and no murmurs were heard. In the abdomen a large mass was felt in the right upper quadrant which extended down below the umbilicus and occupied the region of the kidney. It was smooth and firm, the edges were rounded, and it moved with respirations. The left kidney was not palpable. There was a pitting edema of both lower extremities. The clinical diagnosis made was organic heart disease with decompensation, and the mass in the abdomen was interpreted as a renal tumor.

The electrocardiogram was essentially normal. Urinalysis showed 2 plus albumin on several occasions. Blood examination revealed hemoglobin, 80 per cent; red blood cells, 4,750,000; and white blood cells, 9,560; no abnormal blood cells were noted. The blood Wassermann test was negative. Blood chemistry revealed a urea nitrogen of 35 milligrams and creatinine 2.36 milligrams per 100 cubic centimeters of blood. Examination by Dr. C. H. Warfield of an anteroposterior roentgenogram showed a homogeneous soft tissue mass in the right upper quadrant. Intravenous injection of hippuran showed good visualization of the pelvis and calyces on the right side. The pelvis and superior major calyx were displaced and depressed downward and laterally by the previously described tumor mass (Fig. 1). The impression was that the tumor mass apparently did not originate from the pelvis or superior calyx of the kidney. Roentgenograms of the gastro-intestinal tract and chest were negative.

The patient promptly improved upon cardiac management and after 3 weeks it was deemed advisable to transfer him to the genito-urinary ward for nephrectomy. At operation a well encapsulated tumor mass was found in the right flank with a normal appearing adrenal gland on the upper pole. The kidney appeared intact and was attached to the tumor mass on its lower medial border.

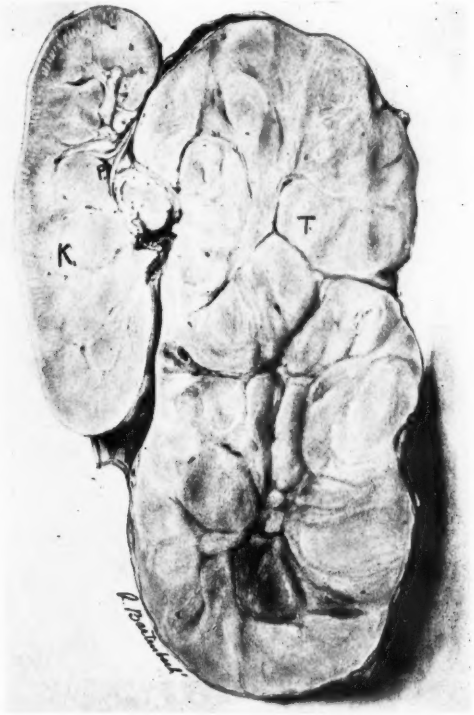
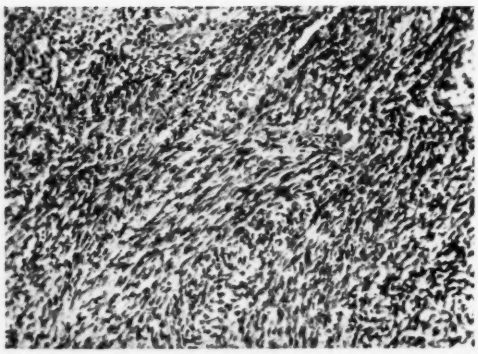
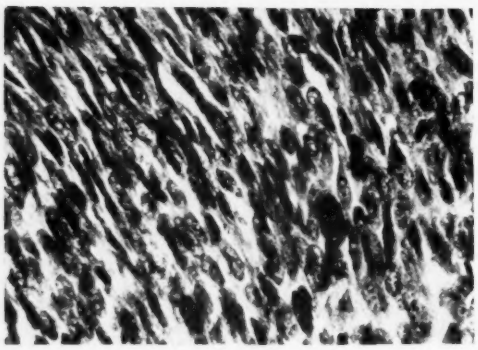


Fig. 2. Case 1. Drawing illustrates the tumor of the renal hilus compressing the kidney. *K*, kidney; *P*, compressed renal pelvis; *T*, lobulated tumor mass.

Following the operation the patient ran a low grade fever, his pulse was of a poor quality, and a seropurulent material freely drained from the wound. He became septic, developed severe chills, and went into coma. Uremia developed and he expired 3 weeks after the nephrectomy. Permission for a necropsy was not given.

Surgical specimen. The specimen (No. 881-35) consists of a kidney which is adherent to a large, firm mass measuring 22 by 15 by 8 centimeters. The mass fuses with the kidney at the renal hilus and although the renal pelvis is markedly compressed, it can be well identified. The tumor is covered by a smooth, thin, dense fibrous capsule which is firmly adherent to the underlying tissue. The surface is irregularly nodular and light purple gray in color. On sectioning, the surface of the tumor mass is meat-like, light purple gray to purplish white, and subdivided into lobules by strands of connective tissue (Fig. 2). The tumor compresses the renal pelvis, obscures the inferior calyx, and is sharply demarcated from the medulla of the kidney. Loosely adherent to the upper pole of the tumor is the adrenal gland, much flattened but otherwise unchanged. The cortex is bright light yellow and the medulla distinct.





Figs. 3 and 4. Case 1. Photomicrographs (low and high power) of the tumor.

The kidney adjacent to the mass measures 11 by 3 by 3 centimeters. It is firm, the capsule is thin and strips with ease leaving a smooth pale purple gray surface. The cortex measures 4 millimeters in thickness, and the renal pelvis for the most part is obscured by the tumor. The superior calyx, although markedly compressed, can be recognized.

Microscopic examination of sections taken from different sites of the tumor revealed a uniform picture throughout. The tumor was found to be very cellular and composed of sheets and interlacing bundles of spindle shaped cells with elongated and hyperchromatic nuclei (Fig. 3). In places the nuclei were irregular in shape and mitotic figures were frequently seen (Fig. 4). Van Gieson's stain revealed a varying amount of stroma composed of loose fibrillar connective tissue. The tumor was seen to bulge into the renal pelvis, compressing it, but was sharply demarcated from the renal parenchyma by strands of loose fibrillar connective tissue and groups of fat cells (Fig. 5). There was no evidence of any invasion of the kidney proper by the neoplasm.

The normal architecture of the kidney was well preserved. The lumen of the superior major calyx was found compressed by the tumor and was lined by a thickened layer of epithelial cells with early metaplasia into squamous epithelium.

Diagnosis: Fibrosarcoma of the hilus of the right kidney.

Case 2. F. W., a colored female aged 45 years, entered the gynecological service of the Cook County Hospital because she had noticed a mass progressively growing

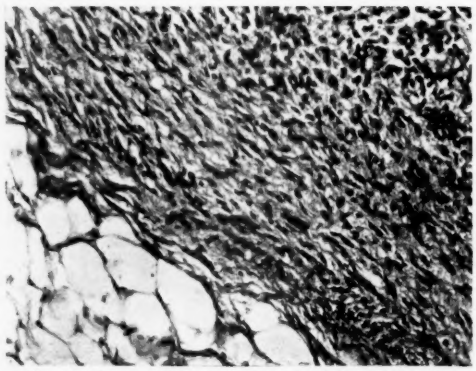


Fig. 5. Case 1. Photomicrograph of the tumor shows the relationship of the tumor to the fat tissue in the region of the renal hilus. Note the spindle cell character of the tumor.

larger in her abdomen for 1 year. Eight months prior to her admission to the hospital pain, which was sharp and burning and felt like a boil, developed in the left side. For the last 3 months nocturia had been present, three to four times each night, associated with frequency and urgency during the day. During the past 3 weeks she had been aware of pain also in her groins and legs of a severe and stabbing character. Her appetite was poor, she was constipated and had lost 17 pounds in weight during the past year. Shortness of breath had been noticeable with moderate exertion.

Her past history was essentially irrelevant. She had rheumatism in 1920, 3 miscarriages, 1 child, and had passed through the menopause 7 years prior to admission.

Physical examination revealed a colored female who did not appear acutely ill. Her temperature was 98.6 degrees; pulse, 88; and respirations, 20. The pupils reacted promptly to light and accommodation. The heart and lungs were essentially negative. The abdomen was found distended and protuberant. Palpation disclosed a large mass on the left side about the size of an 8 months' pregnancy. The mass was nodular, firm, and non-fluctuant. Tenderness was noted throughout, but especially in the left side near the costal margin, and extended to the vertebral spine. The tumor seemed to fill the left quadrant and its lower margin was lost in the pelvis.

Vaginal examination disclosed the uterus to appear continuous with the large mass. The adnexa, especially on the left side, and the tumor mass were extremely tender. Rectal examination gave no additional information.

The diagnosis considered was inflamed fibroids with possible sarcomatous degeneration; left chronic salpingitis or solid tumor of the ovary.

A laparotomy was performed by Dr. J. P. Greenhill. In the region of the left kidney a large tumor mass was found measuring 16 by 10 by 10 inches, which was easily removed. The patient had an uneventful postoperative course and was discharged 15 days later. An attempt was made recently to locate the patient, but her whereabouts remain unknown.

Surgical specimen. The specimen (No. 1177-30) received consists of a large irregular nodular mass, about the size of a man's head, occupying the renal hilus. The nodes are irregularly joined together and in places contain cystic areas. Attached to one aspect of the mass is the markedly de-

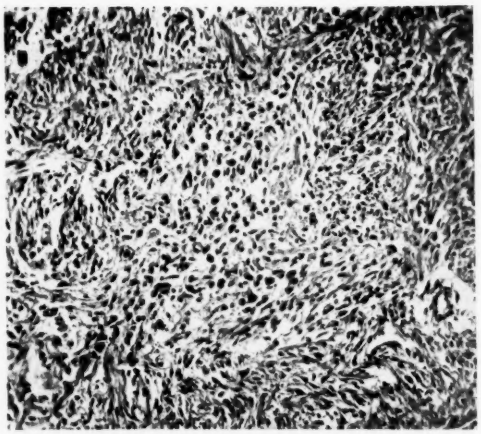


Fig. 6. Case 2. Photomicrograph showing the spindle cell character of the tumor with many hyperchromatic irregular nuclei.

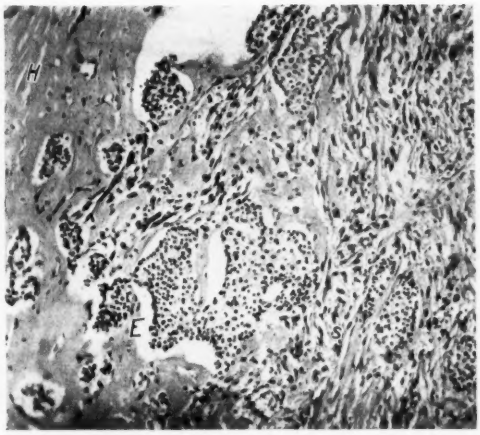


Fig. 7. Case 2. Photomicrograph showing nests of epithelial cells with an ample cytoplasm, *E*. Note the areas of hyalinization, *H*, and sarcomatous areas, *S*.

formed left kidney, stretched out into a thin shell, except at one pole where renal structures are fairly well preserved. On section, the surface of the tumor is mottled purple gray and yellow gray, with extensive areas of hemorrhage. In places there are small cysts, while in other places areas of fibrosis and calcification are found.

The kidney when sectioned is for the most part transformed into an apple sized cavity, surrounded by a thick fibrous capsule.

Microscopic examination of sections taken from different parts of the tumor revealed chiefly bundles of spindle cells, with irregular, hyperchromatic nuclei. Here and there were seen giant cells (Fig. 6). There were numerous areas in which the tumor tissue was necrotic. In the periphery, imbedded in dense connective tissue were islands of large clear cells, with distinct cell membranes, an ample cytoplasm, and small round nuclei (Fig. 7). In addition to these areas and nearby were small groups of dark nucleated round and cuboidal cells arranged in coils and columns.

The compressed kidney showed advanced atrophic changes, especially of the tubules. Some of the tubules near the pelvis were dilated. The stroma was increased and the arteries were moderately sclerosed. The intact glomeruli showed a widening of Bowman's space and a thickening of the capsule. There was no invasion of the kidney by the tumor mass.

Diagnosis: Mixed tumor of the renal hilus with sarcomatous transformation and marked regressive changes. Atrophic changes of the renal parenchyma and hydronephrosis.

Tumors originating from the region of the renal hilus are practically impossible to diagnose during life, and their true nature is disclosed only at operation or at necropsy. They usually manifest themselves clinically as a rapidly growing tumor mass, which is associated with much pain, the pain frequently being referred to the back. Hematuria is absent until the mucosa of the renal pelvis is invaded by the neoplasm.

Pyelography is of great diagnostic aid, especially the method employing the retrograde route. The kidney is usually displaced, and the renal pelvis and calyces are compressed and show a filling defect which is the result of pressure of the neoplasm.

The mortality of sarcoma of the hilus of the kidney is extremely high, and this may be due to the fact that these tumors grow very rapidly producing little or no clinical manifestations and when the patients present themselves to the doctor the tumor has already attained an enormous size.

In the first case, except for the lumbar pain, the patient was unaware of the presence of a tumor mass. His chief complaints were referable to the heart. In the second case, symptoms were present for 1 year before the patient sought medical aid.

In both cases the kidney was found much compressed, showing atrophic changes but no invasion by the neoplasm. Hydronephrosis, which is a common complication due to pressure of the tumor upon the renal pelvis and ureter, was present in the second case only.

In both cases the tumors were very anaplastic and grew very rapidly but no metastasis was evident, either clinically or at operation. Because of their location and their intimate relationship to the kidney, these tumors seemed to have originated from the mesenchyma of the hilus of the kidney.

Some of these so called retroperitoneal sarcomas, the starting point of which heretofore has been obscure, may take their origin from the region of the renal hilus.

CONCLUSIONS

Two cases of sarcoma originating in the region of the renal hilus are presented: a fibrosarcoma and a mixed tumor with sarcomatous elements.

The true character of the neoplasm in each instance was not suspected before operation. The diagnosis was made from the pathological examination of the excised specimens.

Clinically this condition presents vague symptoms, and the diagnosis is usually made very late. It may be well to remember that tumors found compressing the kidney may have their origin in the renal hilus, which may help to explain the origin of some of the obscure sarcomas located either in the perirenal or retroperitoneal tissue.

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INTERLOCKING OSTEOPLASTIC CRANIAL FLAP

A Method to Prevent Lateral Movement

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WHEN the bone flap of the conventional osteoplastic flap is replaced, there is nothing, so far as the shape of the bone is concerned, to prevent lateral movement of the flap. By holding the Gigli saw at an angle it has long been customary to bevel the bone edges so as to prevent the flap from falling in, but nothing has been done to mortise the bone edges so as to prevent lateral movement.

By reversing the direction of the Gigli saw half way between the trephine holes, as shown in Figure 1, a mortise notch can easily be made. The notch may be made pointed or square. The square notch makes for better locking than the pointed. If three or four notches are made in the bone, an interlocking flap which prevents lateral movement results and a better fit is obtained than by the conventional flap without notches. The saw may break unless care is taken to avoid its being pinched by the bone edges as the abrupt turn in direction of the saw is made. This can be avoided if the direction of the saw is not changed too suddenly or if the groove is widened a little with the saw just before its direction is reversed.

At the time the direction of the saw is changed to make the mortised notch, the saw can be drawn so as to bevel the notch in the plane opposite from that which was used to bevel the rest of the flap.

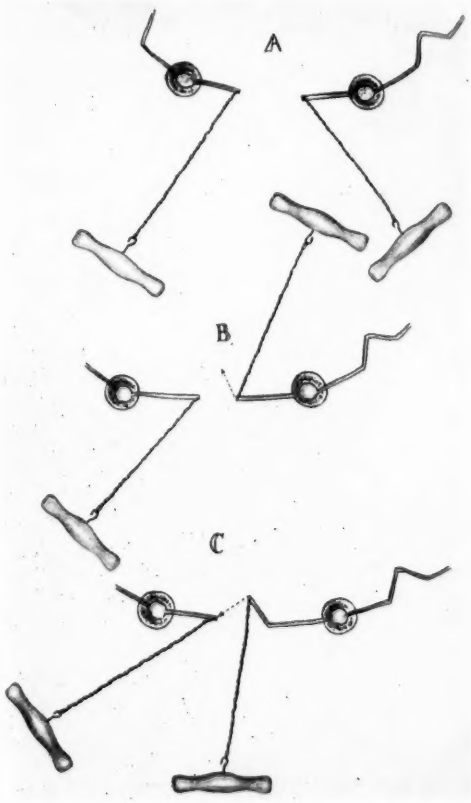

Fig. 1. Formation of interlocking mortised notch.

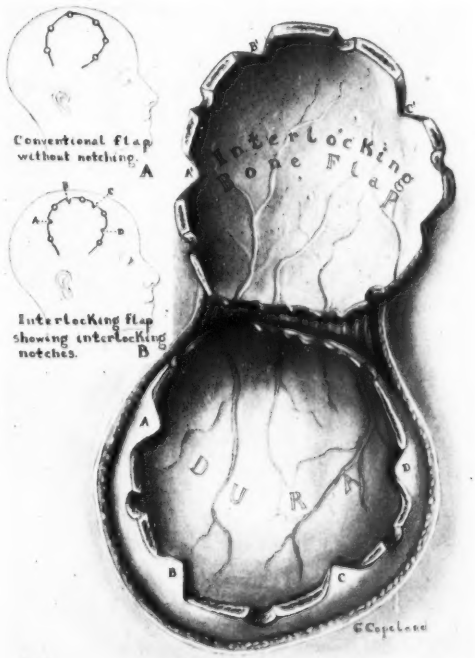

Fig. 2. Flap reflected, showing notches at A, B, C, D.

I have used an interlocking flap made in this manner for a number of years and it has proved highly satisfactory. The procedure is simple and this type of flap offers sufficient advantages to make it preferable to the ordinary beveled flap without interlocking notches.

INJURIES OF THE HANDS DUE TO SHATTERED PORCELAIN HANDLES OF WATER FAUCETS

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THE porcelain handles of water faucets, so commonly used in many homes and hotels, are a potential source of serious injury to the hands. This simple fixture does not usually receive attention until some form of injury occurs. The injury may be a mild abrasion of the skin and the immediate subcutaneous tissues, in which case the wound is quickly cleansed with an antiseptic solution and permitted to heal without any further discomfort, or it may be a more serious injury, such as a deep laceration of the palm or fingers, in which instance one or more tendons or nerves may be severed.

Two types of porcelain handles are in common use. The first type has a metal core which extends the entire length of the porcelain and is attached to the water faucet by means of a screw inserted through the core. The other type is one in which the porcelain is cemented over a metal core or about a central metal hub with plaster of Paris; the four porcelain arms protrude in the form of a cross (Fig. 1). The latter type is more likely to break than is the former. When force is applied to the porcelain handle, usually in the presence of a leaking faucet, one of the porcelain arms shatters and a jagged edge of porcelain lacerates the hand. This type of injury may be superficial or deep, depending on the degree of force applied to the porcelain.

In the past 5 years we have observed 12 injuries of this type at the clinic (Table I). In 9 cases the injury involved the right hand and in 3 cases it involved the left hand. The nature of the injuries is shown in Figure 2. Five of the patients were treated immediately or soon after the accident had occurred. The remaining 7 patients came to the clinic at a later date because of deformity and disability of the hands which were the result of infection or were caused by laceration of one or more nerves or tendons.

The surgeon who sees the patient immediately after the accident has the best opportunity to secure a satisfactory result. It is at this time, when the structures underlying the injury are relatively in their true anatomic relations, that a clearer vision and approximation of the severed fragments of nerves or tendons may be obtained. After cicatrization has occurred at the site of injury, and after the underlying structures have become hopelessly bound together by scar tissue, the surgical treatment and prognosis for complete return of function of the part involved are often unsatisfactory, regardless of the skill of the surgeon.

These injuries may vary greatly in the extent of their severity, depending on the depth of the laceration. The more superficial the laceration, the less is the damage that is done. One must remember that while a small wound of the skin may be present, severe deep injury may occur with involvement of nerves and tendons. Careful examination previous to operation is essential. One should apply a temporary hemostatic dressing and then carefully examine for injury to the tendons or nerves by asking the patient to perform movements of all fingers and by testing sensation over the entire hand. The best possible estimate of injury must be made at this time. One cannot always be certain of the extent of injury, because a tendon occasionally may be severely, but not completely, severed. This may give a false impression of the situation. Such a laceration may be overlooked and at a later date the tendon may rupture spontaneously.

When the diagnosis has been made and the extent of injury has been carefully estimated, treatment should be carried out under the best surgical

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facilities available. These accidents should be regarded as major injuries and treated by operation in a well equipped operating room. The mistake is often made of treating these as minor injuries; the injured parts are not sutured at all or are sutured with the aid of local anesthesia in the presence of a poorly prepared operative field.

The choice of anesthesia is important. We prefer to use brachial plexus block because, when this type of anesthesia is used, the patient usually can move the tendons, which facilitates localization of the proximal ends of the tendons. When operation is prolonged beyond the duration of anesthesia, a general anesthetic may be necessary after the brachial plexus block has served its purpose in helping to localize the severed ends of tendons.

In repairing these wounds the arrest of hemorrhage, when present, by some method that does not add contamination and trauma is the first essential. This may be accomplished by a tourniquet, preferably the cuff of a sphygmomanometer. By inflating the cuff with air, sufficient pressure may be applied over the vessels to control the bleeding. The wound should be carefully cleansed with water and tincture of green soap. It is not necessary to add undue trauma by scrubbing the injured tissues or applying strong antiseptic solutions because these wounds are usually clean and do not require very active preparation for closure. We wish to emphasize the importance of a very thorough examination of the wound for severed nerves and tendons. Each severed tendon and nerve should be carefully searched for, as one must remember that the proximal end is retracted upward and a second incision along the wrist above the annular ligament often may be necessary. It should be remembered that the injury usually is acquired while the fingers and thumb are in extreme flexion, so that a short distal fragment which is often left may be difficult to find. Thorough débridement of the wound should be performed when necessary. The severed tendons and nerves are sutured with fine silk. The ends of the tendons are accurately approximated, the sutures are placed so that they will not pull out through the end of the tendon, and the knots are tied so that they are buried between the ends of the tendon. When the ends of the tendons are frayed, it is better to cut them off squarely so that accurate approximation may be accomplished. The wound is usually closed without drainage by means of black silk or dermal sutures. The hand is bandaged, but a splint is seldom used. If for any reason a splint is necessary, it should be removed on the second or third day and physical therapy started gradually.

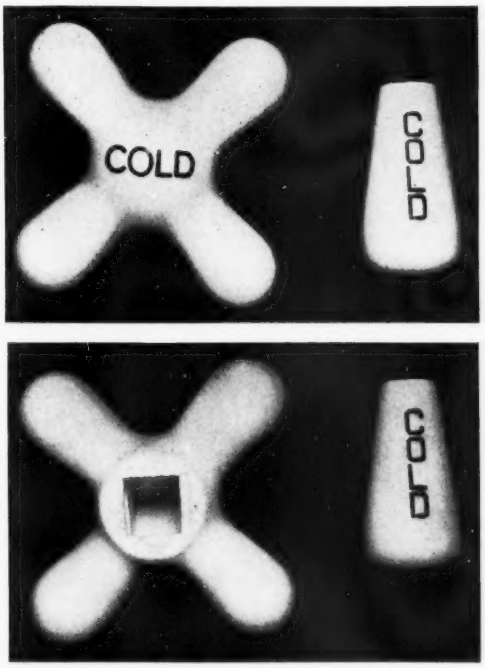

Fig. 1. Top and bottom views of porcelain handles.

When thorough examination is not done at the time of the repair, a tendon which was partially severed may completely separate at some later date and the patient may come to the surgeon complaining of a deformity and paresthesia. Examination of the patient at this time may reveal disability or deformity, such as loss of movement of a portion of, or even an entire, finger, contracture of one or more fingers, atrophy of muscles, or anesthesia of part of the hand. Before operation, a very careful neurologic examination of the hand should be made in order to determine, if possible, just what nerve or nerves have been severed and to obtain an accurate check on the return of function at a later date. The resulting deformity usually is a real source of worry to the patient, who may expect too much of the plastic operation; therefore, it is advisable to inform him just what he may look forward to, so that undue embarrassment, in the event of failure of the operation to achieve the desired result, may be eliminated or at least minimized.

Extensive lacerations, in which there has been considerable damage to tendons, present a different problem. In these cases it may become necessary to use tendon grafts, since the trauma

TABLE I.—TYPE OF INJURY AND RESULT OF TREATMENT

Case	Reason for consultation	Extremity	Extent of the injury	Tendon involved	Nerve involved	Secondary exploration	Wound sutured at time of injury	Tendons and nerves sutured at time of injury	Tendon graft required	Infection present	Results of treatment
1	Laceration	Right	Deep	Flexor pollicis longus	Branch of median	No	Yes	Yes	No	No	Good
2	Deformity or disability; paresthesias	Right	Deep	Flexor digitorum sublimis and profundus	Branch of ulnar	Yes	Yes	Yes	No	No	Poor
3	Deformity or disability	Left	Deep	Flexor digitorum profundus	None	Yes	Yes	Yes	Yes	Yes	Fair
4	Laceration	Right	Superficial	None	None	No	Yes	No	No	No	Good
5	Deformity or disability; paresthesias	Right	Deep	Flexor digitorum profundus	Branch of median	Yes	Yes	?	No	No	?
6	Deformity or disability; paresthesias	Right	Deep	Flexor pollicis longus	Branch of median	Yes	Yes	?	No	No	Good
7	Laceration	Right	Superficial	None	None	Yes	No	No	No	No	Good
8	Deformity or disability	Right	Deep	Flexor pollicis longus	None	?	?	?	No	No	?
9	Laceration	Left	Deep	Flexor pollicis longus	Branch of median	Yes	Yes	Yes	No	No	Good
10	Laceration	Right	Deep	Flexor pollicis longus	None	Yes	Yes	Yes	No	No	Fair
11	Deformity or disability; paresthesias	Right	Deep	Flexor pollicis longus	Branch of median	Yes	Yes	Yes	No	No	?
12	Laceration	Left	Superficial	None	None	Yes	Yes	No	No	No	Good

to the involved structures prevents the approximation of the fragments and in cases in which treatment has been delayed, marked contraction of the proximal end of the tendon may have occurred. The palmaris longus tendon, or sections of the peroneal tendons may be used as grafts. The graft should be carefully measured, fitted in between the severed fragments, and sutured with silk. The wound then should be closed and the hand bandaged.

One cannot stress aseptic technique too much. An infection in one of these injuries usually results in some type of deformity. A large denuded portion of the palm or fingers may require not only tendon grafts, but also a skin graft. Dissection of the underlying fragments which have become buried in the scar tissue as the result of infection is very difficult and the outcome is usually poor even in the most skillful hands.

We have found that the tendon of the flexor pollicis longus muscle is most frequently severed in these cases. This observation is frequently overlooked when the examiner's attention is focused on adduction and abduction of the thumb. Unless all movements of the thumb are tested at the time of the initial injury the patient may return several months later because of the inability to flex the distal phalanx of the thumb voluntarily as in holding a pen.

Next in frequency of occurrence is the injury to one or more tendons of the flexor digitorum sublimis muscle. In these injuries the deformity, as a result of the severed nerves and tendons, is usually recognized at once and the proper type of treatment is instituted.

There may be partial or even complete anesthesia of the tissues innervated by the branches of the ulnar and median nerves. The lacerations may extend deep enough to sever one of the larger branches or several of the fine filaments. When a large nerve has been severed primary suture affords better functional results than do dissection of scar tissue and secondary repair at a later date. The nerve ends are approximated by means of the finest grade of silk suture material. Here a very fine needle is used and the suture is passed through only the epineurium. Secondary suture is not as satisfactory as the primary approximation because the fibers become lost in the mass of scar tissue. Neuromas at the ends of the filaments are common and must be excised before anastomosis is performed.

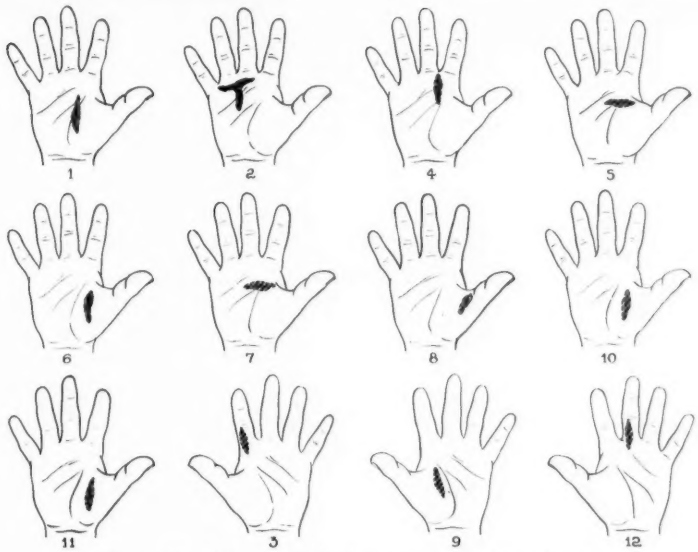

Fig. 2. Site of lacerations in the cases presented in this series.

REPORT OF CASES

CASE 1. An office manager, aged 44 years, came immediately to the hospital after he had lacerated the thenar eminence of his right hand on a porcelain handle of a water faucet on June 27, 1930. An emergency operation was performed. There was considerable bleeding. The wound was opened, and it was found that the laceration extended through the deep palmar arch. Accurate hemostasis of the bleeding vessels was accomplished by placing a tourniquet around the arm. It was necessary to extend the incision down over the wrist and split the annular ligament in order to find the proximal end of the severed tendon of the flexor pollicis longus muscle. The ends of the tendon were approximated and sutured. One branch of the median nerve was sutured and the wound was closed. A splint was applied.

In December, 1935, the patient reported that he has good function in the thumb and that sensation has returned in the index finger.

CASE 2. A veterinarian, aged 44 years, registered at the clinic on October 15, 1930, complaining of loss of flexion of the distal phalanges of the middle and ring fingers, partial loss of extension of the little finger, and numbness of the little finger and ulnar half of the ring finger of the right hand. On August 17, 1930, he had lacerated the palm of his right hand on the jagged edge of the porcelain handle of a water faucet. Severed tendons, which had been observed at the time of the injury, had been sutured immediately after the accident. The wound had healed by first intention. Examination at the clinic revealed a transverse scar at the base of the middle, ring, and little fingers, and a longitudinal scar which extended from the metacarpophalangeal junction to the middle of the palm. The patient was unable to flex the distal phalanges of the middle and little fingers or to straighten the ring finger further than an angle of 160 degrees. A neurologic examination disclosed an injury of the cutaneous branches of the ulnar nerve. On October 23, 1930, an incision was made along the ulnar border of the middle finger. The distal end of the tendon of the flexor digitorum profundus muscle was attached to one of the tendons of the flexor digitorum sublimus tendons and was curled up on itself. The proximal end of the lacerated tendon could not be reached, so another incision was made over the wrist and the annular ligament was divided. The proximal end of the tendon was found in a sheath which was filled largely with a gelatinous material and scar tissue. The ends of the tendon were freed and sutured. When the operation was completed it was noted that the patient could move the distal phalanx of his middle finger without difficulty. It was thought best to repair the tendon of the little finger at a later date because of the time required.

A report which was received from the patient in December, 1935, revealed that there has been little, if any, improvement. The tendon of the little finger has not been repaired.

CASE 3. A stenographer, aged 27 years, registered at the clinic on February 13, 1931, complaining of stiffness caused by a lacerated wound of the left index finger which had failed to heal. Four weeks before the patient came to the clinic, she had cut her finger on the porcelain handle of a water faucet and a physician had sutured a severed tendon. Examination at the clinic on February 13, 1931, revealed an infection at the base of the left index finger. Warm moist dressings were applied. On February 19, 1931, a small amount of necrotic material was removed from the region at the base of the left index finger, and at that time the proximal end of the tendon of the flexor digitorum profundus muscle could be seen in the wound. The wound was cleansed and active and passive motion of the hand was employed to limber up the fingers. On February 27, 1931, a small crust was seen in the wound; at this time, it was noted that the fingers could be moved more freely. The patient was advised to return to the clinic in 6 weeks. On March 13, 1931, more necrotic material was removed, and the fingers were manipulated while the patient was

under anesthesia. On April 22, 1931, operation revealed considerable scar tissue along the palmar surface of the left index finger. The scar tissue extended over the head of the second metacarpal bone and down to the distal phalanx. The scar tissue was excised. The proximal and distal ends of the tendon of the flexor digitorum profundus muscle were freed from the scar tissue. A section of the tendon of the peroneus longus muscle was removed from the left foot and a piece of fascia lata was removed from the left thigh. The ends of the section of the tendon of the peroneus longus were sutured to the proximal and distal portions of the tendon of the flexor digitorum profundus. The piece of fascia lata was wrapped around the tendon graft. A full thickness graft of skin was used to close the wound. At the completion of the operation the patient was able to flex the index finger. A plaster-of-Paris cast was used to support the fingers.

A report which was received from the patient in December, 1935, revealed that the action of the finger has been much improved.

CASE 4. A housewife, aged 37 years, was brought to the hospital on September 21, 1931, complaining of a laceration of the palmar surface of the right hand, between the index and middle fingers. The injury had been sustained on the porcelain handle of a water faucet. Examination revealed a superficial laceration of the right palm; the nerves and tendons had not been injured. The wound was thoroughly cleansed, sutured, and dressed.

A report which was received from the patient in December, 1935, revealed that complete improvement has occurred.

CASE 5. A man, aged 22 years, who was an officer in the Salvation Army, registered at the clinic on May 2, 1932, complaining of deformities of the middle and index fingers of the right hand, which were associated with numbness of the middle and ring fingers. Four months before he came to the clinic, he had cut the palm of his right hand on the porcelain handle of a water faucet; immediately after the injury, he had been unable to flex the index and middle fingers. The numbness of the middle and ring fingers also had occurred immediately after the injury. Examination at the clinic revealed a healed scar which was ¾ inch (1.9 centimeters) long and situated in the median line of the palm, at 1½ inches (3.77 centimeters) below the wrist. There was venous stasis over the index and middle fingers, and the patient was unable to flex the distal phalanx of the index finger. There was some impairment of sensation over the index finger and thumb. On May 5, 1932, operation revealed a division of the median nerve just proximal to the junction of the superficial and deep branches. The nerve was sutured without any great tension of the proximal segments. The proximal and distal portions of the tendon of the flexor digitorum profundus muscle were found attached deep in the palm and adherent to the sheath of the flexor tendon of the second finger. These were loosened and approximated by sutures. A plaster-of-Paris cast was used to support the fingers.

An inquiry was mailed to this patient in December, 1935, but no answer has been received.

CASE 6. A school teacher, aged 29 years, registered at the clinic on October 8, 1932, complaining of anesthesia over the palmar surface of the right thumb and loss of flexion of this digit. Three months before the patient came to the clinic, she had cut her hand on the porcelain handle of a water faucet. The wound had healed by primary intention. Examination of the right hand revealed a scar 1 inch (1.27 centimeters) long over the thenar eminence of the left hand. The patient was unable to flex the distal phalanx of the thumb and there was anesthesia over the distribution of the median nerve to the thumb. On February 4, 1933, an incision was made along the base of the thenar eminence of the right hand. A branch of the median nerve was found to be severed at its junction with the main trunk. The proximal end of the severed branch was rolled up and adherent to the scar tissue. The severed portion of the nerve included the branches to the thumb and index finger. The ends of the severed nerve were freshened up and sutured. The dissection was carried down beneath the nerve, and the distal end of the tendon of the flexor pollicis longus muscle was found without difficulty. An incision was then made above the annular ligament, and by manipulation of the tendon under the annular ligament its proximal end was found adherent in the scar. Both ends of the tendon were freshened and sutured. At the completion of the operation it was noted that the patient could flex the distal phalanx of her thumb.

A report which was received from this patient in December, 1935, revealed that the action of her thumb has been much improved and that there has been some return of sensation.

CASE 7. A student, aged 15 years, entered the hospital on July 30, 1933, complaining of a laceration on the palm of the right hand, which had been sustained on the porcelain handle of a water faucet. Examination revealed a superficial laceration 1 inch (1.27 centimeters) long on the palm of the right hand. There was no evidence of injury of the nerves or tendons. The wound was cleansed and dressed.

A report which was received from this patient in December, 1935, revealed that the wound has healed and that there is no deformity of any kind.

CASE 8. A housewife, aged 39 years, registered at the clinic on August 28, 1933. She came for a general examination and at that time requested advice concerning an old injury to her right thumb. On June 15, 1933, she had cut her thumb on the porcelain handle of a water faucet. Examination of the right hand revealed a healed laceration of the palmar surface of the right thumb. The tendon of the flexor pollicis longus muscle was adherent to scar tissue. There was 10 degrees of motion in the distal phalanx of the thumb. Physical therapy was advised.

CASE 9. A salesman, aged 34 years, entered the hospital on April 5, 1934, complaining of a laceration of the palm of his left hand, which had been sustained on the porcelain handle of a water faucet. Examination of the hand revealed a laceration ¼ inch (0.64 centimeter) long, situated over the thenar eminence of the left hand. A small piece of porcelain was removed from the wound. A careful exploration did not reveal any injury of tendons or nerves. The wound was sutured and dressed. On April 18, 1934, the patient was unable to flex his left thumb. At that time it was thought that the tendon of the flexor pollicis longus muscle had been cut or was adherent in scar tissue. On April 23, 1934, there was loss of sensation over the palmar surface of the distal phalanx of the thumb. On April 24, 1934, an operation was performed. An incision was made along the thenar eminence of the left hand. The subcutaneous tissues were separated and considerable scar tissue was found beneath the wound. This was dissected free and the end of the branch of a nerve was found in the scar tissue. The dissection was extended along the flexor surface of the thumb for ½ inch (0.64 centimeter) until we found the severed ends of the tendon of the flexor pollicis longus lying free. An incision was made on the flexor surface of the wrist above the annular ligament and extended down to the proximal end of the tendon. The tendon was pulled up and a suture was inserted. A probe was inserted along the tendon sheath under the annular ligament to the first wound and the proximal end of the tendon was passed through the sheath and sutured to the

distal end. The branches of the median nerve could be seen. One large branch to the thumb was intact, but a smaller branch had been severed. The severed ends were sutured.

A report which was received from this patient in December, 1935, revealed that there has been marked improvement in action and sensation of the thumb.

CASE 10. A dentist, aged 45 years, entered the hospital on July 10, 1934, complaining of a deep laceration of the thenar eminence of the right hand, which had been sustained on the porcelain handle of a water faucet. Examination of the right hand revealed that the tendon of the flexor pollicis muscle had been severed just opposite the base of the thumb. It was necessary to make a long incision above the annular ligament in order to find the upper end of the tendon. A probe was passed down through the tendon sheath beneath the annular ligament, and the proximal part of the tendon was pulled through this sheath and sutured to the distal end. At the end of the operation it was noted that the patient could flex his thumb.

A report which was received from this patient in December, 1935, revealed that approximately 50 per cent of the function of the thumb has returned.

CASE 11. An instructor, aged 26 years, registered at the clinic on August 27, 1935, complaining of tingling in the right index finger and thumb and loss of flexion of the distal phalanx of the thumb. On March 16, 1935, he had cut the thenar eminence of his right hand on the porcelain handle of a water faucet. The laceration had been sutured but an abscess had developed in the wound. Examination of the right hand disclosed a thick scar over the thenar eminence of the right hand with approximately 50 per cent loss of abduction of the thumb and complete loss of voluntary flexion of the distal phalanx. There was some anesthesia over the lateral surface of the index finger and over the medial surface of the thumb. On November 3, 1935, an incision was made over the right thenar eminence, just lateral to the scar. The underlying tissues were freed and one of the branches of the nerve to the thumb was isolated. By deeper dissection, it was possible to find the distal end of the tendon of the flexor pollicis longus muscle, which was very short. Another incision was made over the palmar surface of the wrist, above the annular ligament, and the proximal fragment of the tendon was found. It was adherent to its sheath, beneath the annular ligament. The tendon was freed and brought up into position, but approximation of the two ends could not be accomplished, so a section of the tendon of the palmaris longus muscle was removed and used as a graft. The proximal end of the median nerve beneath the transverse carpal ligament was isolated and the neuroma was removed. The proximal end was then sutured by accurate end-to-end anastomosis to the two distal stumps of segments going to the thumb and index finger. A splint was applied and the hand was kept in slight flexion.

There was almost complete recovery of function and marked diminution of anesthesia in May, 1936.

CASE 12. A housewife, aged 30 years, entered the hospital on October 15, 1935, complaining of a laceration of her left hand, which had been sustained on the porcelain handle of a water faucet. Examination of the left hand revealed a laceration ¾ inch (1.9 centimeters) long, situated over the lateral palmar surface of the third finger. There was no evidence of injury of nerves or tendons. The wound was cleansed, sutured, and dressed.

A report which was received from this patient in December, 1935, revealed that the wound has healed completely and that the patient has had no further trouble with her hand.

SUMMARY

Porcelain handles of water faucets are a potential source of serious injury to the hands. The surgeon who sees the patient immediately after the injury has the greatest responsibility and the best opportunity for securing a favorable result. The use of brachial block and general anesthesia has been discussed. The acute injuries of the hand should be carefully cleansed, thoroughly examined, and properly treated so that latent deformity, which may be the result of infection or severed tendons and nerves, can be prevented or at least minimized. The tendon of the flexor pollicis longus muscle and the branches of the median nerve were found to be parts most frequently involved in this type of injury. When the lacerations are extensive it may be necessary to use tendon grafts and skin grafts. Suture of nerves, when indicated, should be performed at once. In cases in which this is delayed, a careful neurologic examination should be made so that secondary suture may be facilitated at the time of exploration. Active movement of the hand and physical therapy should be instituted very early.

MORTALITY IN SURGICAL DIABETES—CRITERIA AND TECHNIQUE IN EXTREMITY LESIONS

Five Year Study of 496 Cases

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THE fact that diabetes is more diligently sought after and detected, together with the fact that modern insulin therapy has almost completely eliminated death from coma, makes it possible for the diabetic patient to live longer and thus to be confronted with all the other pathological conditions common to their age group. Outstanding among such conditions are those requiring surgical treatment. Before the discovery of insulin, the diabetic was fortunate if he survived. If his condition became surgically complicated, he was, in the vast majority of instances, doomed. With insulin therapy the surgical risk in the diabetic has been constantly lessened until now, under good conditions, it should compare favorably with that of the nondiabetic. The staffs of hospitals generally are divided into medical and surgical services and there arises therefore a difficult problem in the adequate management of the diabetic patients. While they are being treated on the surgical service, the detailed complicated medical treatment must also be carried out. In the Morrisania City Hospital we found this problem especially pressing since the hospital is located in the Bronx in a community predominately Jewish.

The old method of administering medical care on surgical wards by means of request consultations proved unsatisfactory. The medical follow-up was inadequate; there was a division of responsibility, and in all, the control of the diabetic was poor. Naturally, the result of surgical treatment was not good and this led to hesitation on the part of the surgeon to attempt operative treatment. All of these factors produced a staggering mortality. This fact was noticed the first year the hospital was opened. The statistics for diabetic amputation for the year 1931 were reviewed, and it was found that in 6 cases of 7 amputations patients succumbed, a mortality of 85 per cent. These results were in such marked contrast to those from institutions doing special work in this field that it was decided to appoint an internist to care for the diabetics on the surgical service. Thus an organization was begun to provide medical care for the diabetic undergoing surgical treatment.

From the Surgical Services of the Morrisania City Hospital.
Read before the Surgical section of the New York Academy of Medicine at a joint meeting with the New York Diabetes Association, May 1, 1936.

ROUTINE AND ORGANIZATION

A simplified standard routine has been instituted. Standard diets which can be readily ordered by number from the diet kitchen have been established. These diets are arranged in different forms—fluid, concentrated, meat free or regular—and in number as to the amount of the diet. This made for ease in changing the amount of the diet by changing the order of a number. Also the form of the diet can be easily changed to suit the condition of the patient but the amount is not changed so that control of the diabetes is maintained. The diets are moderately high in carbohydrates, the protein requirement is met, and the fat content is kept low. Twenty-four hour urinalyses are done as routine measures. Insulin is ordered only by the internist. The more urgent diabetic conditions are treated by means of the usual methods of giving by mouth orange juice or other suitable, readily available carbohydrates together with adequate insulin and more frequent urinalyses. In the still more desperate cases, glucose infusions and insulin treatments are given and a specimen of urine is taken by catheter for analysis. All patients are seen by the internist, and he alone takes full charge of the medical treatment. His advice is also sought as to the necessity for operation, the time of operation, and, when the lower extremity is involved, his opinion as to the level of amputation or local incision. This seemed best as at first the operative work was done by the attending surgeons in rotation.

The postoperative care of the diabetic patient was also fairly well standardized. On return from the operating room all patients received infusions of 1 liter of normal saline with 25 or 50 grams of glucose, with or without insulin as indicated. The management of carbohydrate metabolism in the period following operation varied according to the surgical indications: infusions and

TABLE I.—MORTALITY OF ALL CASES—OPERATIVE AND NON-OPERATIVE COMBINED

	Total	Deaths	Percentage
First period	49	18	37
Second period			
First year	50	15	30
Second year	145	27	18
Third period	107	19	17
Fourth period	145	19	13

TABLE II.—MORTALITY OF THE TOTAL NON-OPERATIVE CASES—ALL LESIONS COMBINED

	Total	Deaths	Percentage
First period	24	10	41
Second period			
First year	20	5	25
Second year	72	10	14
Third period	54	8	15
Fourth period	71	7	11

TABLE III.—MORTALITY OF TOTAL OPERATIVE CASES—ALL LESIONS COMBINED

	Total	Deaths	Percentage
First period	16	8	50
Second period			
First year	29	10	34
Second year	64	17	26
Third period	44	11	25
Fourth period	65	13	20

insulin for those who were denied food intake; diet, form of diet, and insulin as indicated. Check of the urine was made frequently to diagnose ketosis early and to avoid hypoglycemia. The patients were returned as quickly as possible to the standard diets and the 24 hour urine tests. Thus the more accurate control of the glycosuria was accomplished. The patients remain in their respective surgical wards—general surgery, urological surgery, and skeletal surgery. The internist makes daily rounds and in addition is called by the house staff when a patient is admitted in urgent condition.

As to the surgical organization, at first each surgeon operated in rotation. This system was followed for the 2 years, 1932 and 1933. Then 3 men were appointed to do the diabetic amputation operations and this system was practiced during the year 1934. In 1935 one surgeon did all the diabetic amputations. All surgical conditions other than those involving the lower extremities were cared for in rotation by the respective surgeons or specialty surgeons. The house staff was the usual one: a junior interne to each ward and a house surgeon for each service.

RESULTS

In evaluating the results after 4 years with the routine stated we must bear in mind the type of patient admitted, control, and the facilities available for care. No patient can be refused admission. Patients are received who may have had private care, but when confronted with a bad prognosis are referred to the city hospital. Similarly patients are transferred to us from other institutions or are sent to us when they are denied admission to other hospitals. As to the legal control of the patient, no patient can be discharged even though he refuses operation; he can leave only at his own request. Once a case has been considered operative the policy has been followed in all instances to operate whenever consent is obtained; we have been fully cognizant of the fact that in many cases in which there has been delay in obtaining consent the prognosis has been very materially altered. The facilities for care are similar to those of any city hospital ward; 30 beds to a ward, with an average occupancy of 35 to 40 patients cared for by 3 or 4 nurses in the daytime and 1 at night.

For comparison this study is divided by calendar years into four periods according to the organization for care. In the first period, 1931, the old method was practiced: operations by rotating staff surgeons and medical care through request consultation. In the second period, 1932 and 1933, surgical care was given by rotating surgeons and the treatment of the diabetes by one internist. In the third period, 1934, the surgical care was given by an amputation team and one internist. In the fourth period, 1935, one surgeon did all the amputations and one internist took care of the diabetes. All patients with lesions other than of the lower extremity were cared for as in the second period (rotating surgeons and one internist) for all 4 years.

The present surgical regimen in these cases came about because of the great predominance of lower extremity complications over all other conditions, 224 in 496 cases. Since the method has been followed there has been a reduction in mortality from 37 per cent to 13 per cent in all cases both operative and non-operative (Table I).

In the total cases without operation all lesions combined, there was a reduction in mortality from 41 to 11 per cent (Table II). These figures include the patients who refused operation and remained in the hospital until death; the patients who left the hospital at their own request are not included.

In the total cases with operation, all lesions combined, there was a reduction in mortality from 50 to 20 per cent (See Table III).

In all lesions other than of the lower extremities, operative and non-operative combined, there was a reduction of mortality from 28 to 10 per

TABLE IV.—MORTALITY IN ALL LESIONS OTHER THAN LOWER EXTREMITIES—OPERATIVE AND NON-OPERATIVE COMBINED

	Total	Deaths	Percentage
First period	28	8	28
Second period			
First year	26	7	27
Second year	84	10	12
Third year	53	9	17
Fourth year	81	8	10

TABLE V.—MORTALITY IN THE TOTAL LOWER EXTREMITY LESIONS—OPERATIVE AND NON-OPERATIVE COMBINED

	Tota	Deaths	Percentage
First period	21	10	48
Second period			
First year	24	8	35
Second year	61	17	28
Third period	54	10	18
Fourth period	64	12	19

TABLE VI.—MORTALITY IN LOWER EXTREMITY LESIONS WITHOUT OPERATION

	Total	Deaths	Percentage
First period	9	3	33
Second period			
First year	8	2	25
Second year	34	8	23
Third period	23	5	18
Fourth period	28	3	11

cent. These cases include almost every surgical condition met on a general surgical service. They are grouped together, for there is not a sufficient number of each surgical complication to make special studies. In these cases, the surgeons continued to rotate; thus there are only two periods of treatment (Table IV).

In the total lower extremity lesions, operative and non-operative combined, the mortality was reduced from 48 to 19 per cent (Table V).

In the lower extremity lesion cases in which patients were treated without operation, there was a reduction in mortality from 33 to 11 per cent. These figures do not include the patients who left the hospital at their own request. There *are included*, however, those cases in which patients refused operation and remained in the hospital until death (Table VI).

The accompanying chart gives a comparison of the mortality in lower extremity lesions operated upon and the surgical procedures followed. The ordinates indicate the operation performed, the minor procedures are the first half, and the major amputations are the second. Each vertical in the abscissæ represents a single case. In charting the procedures on each case the key at the bottom was followed.

TABLE VII.—AGE AND SEX INCIDENCE AND MORTALITY PERCENTAGE IN SURGICALLY TREATED DIABETIC LESIONS OF THE LOWER EXTREMITY*

Decades	Females			Males			Total		
	Cases	Death	Per cent	Cases	Death	Per cent	Cases	Death	Per cent
4	3	1	33	0	0	0	3	1	33
5	14	3	23	2	0	0	16	3	19
6	16	3	19	18	8	44	34	11	32
7	10	4	40	12	3	25	22	7	27
8	8	3	37	6	4	66	14	7	50
Total	51	14	26	38	15	40	89	29	31

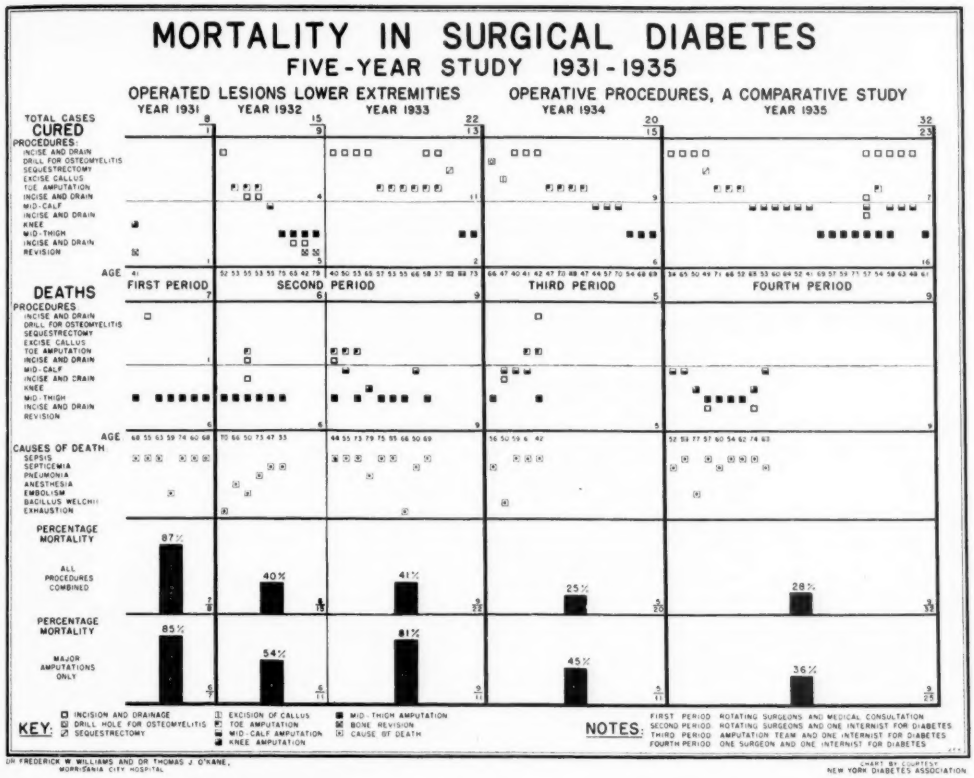
*Cases in the first period of treatment not included.

In the first period—when treatment was administered by rotating surgeons and by medical consultants on request—there was a total of 8 cases, with 1 cure and 7 deaths. The cure was in a case of knee amputation with subsequent bone revision. In the major surgery group there was 1 cure. Of the 7 deaths, 1 followed incision and drainage, while 6 followed primary mid-thigh amputation.

The percentage mortality for the first period, all procedures combined, was 87 per cent, while in the major amputation group the mortality was 85 per cent.

In the first year of the second period, of a total of 15 cases, 9 patients were cured and 6 died. Of the 9 cured, 4 had been subjected to minor surgery, and 5 to major operations. Of the 6 deaths, 5 were after primary mid-thigh amputation, and 1 was after secondary amputation. The percentage mortality for this first year of the second period was, for all procedures combined, 40 per cent, and for major amputations, only 54 per cent.

In the second year of the second period of treatment, of a total of 22 cases, 13 patients were cured and 9 died. Of the 13 cured, 11 had been subjected to minor surgery and 2 to major surgery. Of the 9 deaths, all major surgery cases, 5 followed primary amputations and 4 other procedures. The percentage mortality, all procedures combined, for the second year of the second period was 41 per cent. This was about the same as for the first year of that period, and both were marked improvement over the 87 per cent of the first period. For major amputations only, the percentage mortality for the second year of the second period was 81 per cent. This was decidedly greater than for the first year of the second period; it was almost the same as the 85 per cent for the



first period. This rise in mortality for this group prompted the staff to appoint a team to do amputations in cases with diabetic lower extremity involvement.

In the third period, of a total of 20 cases, 15 patients were cured and 5 died. Of the 15 cured, 6 followed major surgery, with none requiring more than one operation, and 9 followed minor surgery with none requiring more than one operation. All 5 patients who died had been subjected to major surgery, 3 primary amputations and 2 secondary. The percentage mortality for the third period for all procedures combined, was 25 per cent; for major amputations only, 45 per cent.

With this improvement in mortality, one surgeon volunteered to do all the amputations for the next year, which was the fourth period. In this fourth period, of a total of 32 cases, 23 patients were cured and 9 died. Of the 23 cured, 7 had had minor surgery with none requiring more than one operation, and 16 had had major surgical operations, with 11 primary and 5 secondary operations. Of the 7 deaths, none followed primary minor surgery. The mortality for the fourth period, all procedures combined, was 28 per cent; for major amputation only 36 per cent.

The improvement in mortality for the several periods of treatment, all procedures combined is shown in the following summary:

	Per cent
All procedures combined	
For the first period	87
For the second period	40 and 41
For the third period	25
For the fourth period	28
For the major amputations	
For the first period	85
For the second period	54 and 81
For the third period	45
For the fourth period	36

SURGICAL PROBLEM

During the third period, that is the period during which the surgical treatment of lesions of the extremities was being carried on by an amputation team, it was recognized that, if improved

TABLE VIII.—CLASSIFICATION OF LESIONS OF LOWER EXTREMITIES IN DIABETES

A. Infectious
   1. No clinical evidence of circulatory impairment.
   2. Lesion primarily infectious.
   3. No gangrene.
   4. "Four plus infectious."

B. Vascular
   1. Marked clinical evidence of circulatory impairment.
   2. Lesion primarily gangrenous.
   3. No infection.
   4. "Four plus vascular."

C. Mixed
   1. Mixed, one plus vascular.
      a. Slight clinical evidence of circulatory impairment.
      b. Lesion primarily infectious.
      c. No gangrene.
      d. "One plus vascular, mixed."
   2. Mixed, two plus vascular.
      a. Moderate clinical evidence of circulatory impairment.
      b. Lesion primarily infectious.
      c. Gangrene superimposed.
      d. "Two plus vascular, mixed."
   3. Mixed, three plus vascular.
      a. Marked evidence of circulatory impairment.
      b. Lesion primarily gangrenous.
      c. Infection superimposed.
      d. "Three plus vascular, mixed."

results were to be obtained, certain principles not necessarily applicable to surgical procedures in other diseases of the extremity, would have to be followed. With the diabetes under control other factors presented themselves which had to be considered to improve the results. The surgical treatment of lower extremity lesions was of primary importance. Great strides have been made in the surgery of these lesions by others (3, 4, 5, 7, 8), and we believed that we also could improve our results by the intensified study of the problem. During the fourth period we attempted to fit our criteria and procedures to the problems peculiar to the surgical diabetic. It may be stated that our ultimate decision as to the state of the extremity lesion and what type of treatment should be used, depends entirely on clinical observation and examination. No oscillometer or dermatherm is used. Histamine or other similar tests are not made and arteriography is not considered necessary. We believe that the same results are to be obtained by means of careful and detailed clinical methods. As to the local vascular status of the limb, it was found that not infrequently patients over 60 years of age have extremities with vascular supply good enough to warrant further conservative surgery and, conversely, younger patients are encountered who have avascular extremities which require thigh amputation.

CLASSIFICATION

We have classified diabetic lesions of the extremities as (1) purely vascular, (2) purely infectious, (3) mixed (Table VIII).

Vascular lesions. The following factors are the means by which we determine the classification clinically.

1. As to the general condition, the most important factors to study in the history of the patients are: age, associated diseases, type and duration of the lesions, and electrocardiographic changes. Local vascular status is determined by clinical findings, such as—

2. The presence of pain, its location, duration, and type. The pain may be of the intermittent claudication type which comes on after walking or the night pain of arteriosclerotic feet, which is relieved when patient is up and about during the day; it may be the throbbing pain of infection or bone lesion; it may be the pain of arthritis, gout, or arch disturbances. Each type has its characteristics and must be differentiated.

3. The condition of the nails, which may be gnarled and twisted, or of the "oyster-shell" laminated type characteristic of poor circulation. The condition of the skin, its elasticity, dryness, sheen, and tone, all are indicative of the trophic state.

4. The loss of subcutaneous fat and the amount of muscle atrophy.

5. The filling response of the superficial veins to elevation and dependency of the limb. This can be estimated by the rate at which the veins refill on lowering the leg suddenly from a 50 or 60 degree angle to the horizontal.

6. Color changes on dependency and elevation of the limb. When the foot is dependent the degree of extension of rubor or lividity onto the metatarsal area and the depth of the color vary with circulatory status.

7. The level of temperature change as determined by manual palpation.

8. Pulsations of the dorsalis pedis, posterior tibial, popliteal, and femoral vessels and also the condition of their walls. Pulsation in the foot may vary. One or the other (posterior tibial or dorsalis pedis) is often absent and they may be intermittently present. When only one is found pulsating, we may often see in lower leg amputations, our clinical estimation of these vessels graphically illustrated by the avascular condition of the muscles formerly supplied by the nonpulsating artery.

9. Capillary circulation, as determined by response to finger pressure on the skin of the foot at different levels. This is a minor observation;

the rate of return to the original color is determined after pallor is produced by pressure.

10. Roentgenograms of the limb for vessel and bone changes. These are often deceiving as to vascular status because the shadows cast are calcific deposits in the wall of the vessel; hence the patency of the lumen is not indicated.

These ten items constitute our method of determining clinically the vascular state of the limb and the general condition of the patient.

Infectious lesions. The status of the infectious lesions is determined by:

1. General condition of the patient, temperature curve, and toxic state. A history of septic temperature curve and evidence of considerable toxemia indicate an emergency status which makes immediate radical surgery imperative.

2. Locally, the extent of redness, swelling, temperature, fluctuation, discharge, and the presence of lymphangitis and inguinal and femoral adenitis. The last named is of considerable importance because its presence is an indication of the extent of the infection throughout the extremity.

3. Character and extent of gangrene, if present.

4. The type of organism found by smear and culture of local lesions. The presence of hemolytic streptococcus is of considerable prognostic value; prediction as to outcome should be especially guarded when this type of organism is obtained.

5. Blood culture. The significance of bacteriemia and septicemia is, of course, evident.

6. Presence of osteomyelitis either clinically or by roentgen-ray.

7. The response of the local lesion to 24 hour wet dressings in cases in which operation is not immediately urgent.

These 7 items constitute the clinical factors studied in determining the status of the infection of the limb.

Mixed lesions. Mixed lesions consist of varying combinations of the vascular and infectious types. It is easily understandable that in a leg with fairly good vascularity in which ordinarily amputation below the knee might be the operation of choice, amputation above the knee will have to be performed if fairly severe and extensive infection with sepsis is present.

OPERATIVE PROCEDURES

We have come to the conclusion that only four operative procedures are feasible in the surgical treatment of diabetic limbs. This decision does not apply to surgery of the extremities in the presence of other diseases, vascular or otherwise, because only in the diabetic are present the combined factors involved, such as high susceptibility to infection and septicemia and a tendency to early arteriosclerosis. These procedures are: (1) local surgery including incision and drainage, bone excision, or sequestrectomy; (2) toe amputation; (3) calf amputation above the lower third of the leg; (4) thigh amputation at or above the condyles of the femur.

As to technique we believe that primarily minute attention to every detail is the secret of success in surgery of diabetic extremities. The three cardinal factors to which special attention must be directed are: (1) avoidance of infection; (2) preservation of circulation, (3) avoidance of trauma.

With these fundamental principles firmly fixed in mind as our ultimate goal, I shall briefly enumerate the steps we use to attain this end. We make no claim as to originality; we have simply made use of the various known measures and facts in formulating our method.

Skin preparation. When possible the skin is prepared 48 hours before operation. The preparation consists in shaving and scrubbing the extremity with green soap, washing off with alcohol and wrapping the member in sterile towels. This procedure is repeated the day before the patient is taken to the operating room. The gangrenous or infected foot is wrapped separately and is not unwrapped in the operating room.

Operative technique. The method described applies to all procedures:

1. To prevent injury to sclerotic vessels and collateral circulation, a tourniquet is never used. The vessels of diabetic extremities rarely bleed dangerously.

2. To avoid carrying in any possible infection from the skin, the electric knife is used on the skin and fascia and occasionally on the muscles. To avoid injury to collateral vessels, which as a rule come off at right angles to the main vessels, section of skin and muscles is done at right angles to the long axis of the limb.

3. Separation of skin, fascia, and muscle planes is never done.

4. Main vessels are ligated at the lowest possible level. Preferably they are cut off at the muscle level. They are not pulled down but are ligated *en masse* with suture ligature of catgut.

5. All small bleeders and vessels are closed by electrocoagulation.

6. The ends of the bones are treated in no way except that in calf amputations the crest of the tibia is rounded off with a rongeur.

7. In separating muscles from the bone so that the bone may be sectioned at a higher level,

special care is taken to avoid cutting vessels, which lie close to the bone, and the small branches.

8. Nerves are pulled down, ligated, injected with alcohol, and cut.

9. The wound is copiously flushed with hot saline.

10. The skin wound is closed with one silk retention suture inserted only through the skin. Skin clips complete the closure. No tension is permitted anywhere in the wound. Muscles are not sutured.

11. An alcohol gauze dressing is applied to the suture line with several layers of fluff gauze over this.

12. In so far as possible the Lane technique is followed throughout the operation.

13. In infected cases, one suture is applied to the skin only and a rubber tissue drain, to which is tied a piece of silk with long ends, is placed in the wound after the method described by Dr. Beverly C. Smith.

These steps are used in all major operative procedures.

For amputation below the knee we feel that the modified guillotine amputation advocated by Dr. Beverly C. Smith is ideal and fulfills the requirements named. We have slightly modified his technique in that a straight guillotine of soft parts is done first and the bones are then resected at a higher level. In amputation above the knee, we use a modified form of the guillotine amputation, a procedure similar to the *en saucisson* method of the French writers advocated by a number of men (3, 4, 5, 7, 8). This is a step operation—the muscles are cut at the level of retraction of skin and fascia and the bone is cut at a higher level, the incisions are all at right angles to the long axis of the limb.

Postoperative treatment. The postoperative dressing is done by the operator, strictest asepsis and care being observed. If the case is clean and the temperature remains normal the dressing is not taken down for 10 days. In infected cases in which the temperature remains around normal the drain is withdrawn after 2 or 3 days, by means of silk string tied to it, but the dressing is not disturbed. In 4 or 5 days or perhaps a week after the drain has been withdrawn, if there is still no rise in temperature, secondary wound closure of skin only is done with clips.

Consideration of prosthesis. As to the application of future prosthesis we believe that this is of minor importance as compared with the saving of life after so difficult a procedure. Prostheses are so manufactured today that we need not be so concerned as formerly in securing an end weight-bearing stump, for prostheses are now made so that both side weight-bearing and ischial weight-bearing can be utilized successfully (2). Whenever possible amputation below the knee is desirable (1) to preserve the knee joint. Even if only a very short section of tibia can be saved, a knee weight-bearing prosthesis or one crutch with padded knee support can be used.

A study of age and sex incidence and the mortality percentage in the surgical treatment of diabetic lower extremity (Table VII) showed the following:

These lesions occur at an earlier age in females than in males. This may be due to foot fashions. The mortality is generally higher in males than in females. In both sexes the mortality is higher in the early and late decades than in the middle decades. This may be due to the fact that infection plays a big part in early life and that complications due to generalized arterial disease are responsible in the late decades.

SUMMARY

The organization of a service for the care of the diabetic requiring surgery resulted in:

1. A decrease in the mortality of all surgical diabetic cases.

2. A decrease in the operative mortality in all cases.

3. A decrease in the non-operative mortality in all cases.

4. A decrease in the mortality of the diabetic cases requiring surgery other than of the lower extremities.

5. A decrease in the mortality of the cases of lower extremity lesions not operated upon.

Close co-operation between the internist and the surgeon resulted in:

1. A decrease in the total mortality, most marked in the cases involving the lower extremity.

2. An increase in the number of cases with involvement of lower extremity in which minor surgery could be done with good results.

3. A decrease in mortality especially when major amputations were necessary.

CONCLUSIONS

The organization of a service for the care of the diabetic requiring surgery and the close co-operation between the internist and the surgeon are essential for good results in these cases.

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EDITORIALS

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INTERNATIONALISM IN MEDICINE

ON qualifying as a medical practitioner every medical student accepts as a part of the Oath of Hippocrates the statement that he will impart a knowledge of the art to any of his own sons . . . and the disciples bound by a stipulation and oath according to the Law of Medicine. This willingness to impart all new knowledge has always formed one of the ideals of scientific medicine which even in its early days differed from witch and tribal medicine, which were essentially secret. In the gradual progress to modern conditions there have, it is true, been lapses from this ideal so that even surgeons and physicians of repute were known in the past to have fallen victims to the spirit of commercialism and for their own personal gain have kept secret the details of technique in their treatment but; in spite of the fact that the public has always welcomed the quack and has regarded secret knowledge, whether by manual treatment or the sale of patent medicines, as possessing some hidden virtue unknown to qualified doctors; the more noble spirit of the general diffusion of scientific knowledge has gradually grown until today medicine stands in a position curiously alone, in that the physician or surgeon having to make a living by his own efforts and knowledge increases competition against himself by publishing abroad his methods and thus lessens his source of income. The honest surgeon should even go further and should constantly aim by his investigations of preventative medicine to abolish the very operations by which he makes his living. It is to these two factors, the free diffusion of knowledge and research, that the progress of medicine is due and it is in these two characteristics that medicine stands in advance of other sciences. Every surgeon and every physician has had ingrained in him the need of acquiring knowledge from others at first hand and the pleasure and joy that is to be obtained by freely disseminating his own knowledge. In this comradeship of learning there is no national boundary. Even one hundred years ago medical men traveled widely to other countries to improve their knowledge and were always welcomed and given every opportunity of learning foreign methods. Indeed their opportunities were exceptional for even up to forty or fifty years ago there was still a tendency among well known leaders of medicine to evince some hesitation in training those in their immediate neighborhood to become their competitors.

With increased ease of traveling and greater accessibility this international friendship has progressed to a remarkable degree and it can

now be truly said that medicine knows no boundary and recognizes no nationality. Young men are encouraged in every way to travel and to study abroad. In this respect the United States of America has led the way. Its universities and seats of learning have large numbers of traveling scholarships which enable its best and keenest students to study in every civilized capital. The value of such a custom is not only to the student. Every surgeon knows the value of a teaching post and realizes that his own enthusiasm and keenness is kept from flagging by being surrounded by enthusiastic and intelligent young men with whom he has an opportunity of comparing his own observations with those that have been acquired elsewhere.

In theory a subject can be best grasped by careful perusal of a written article but in a busy man's day such perusal is likely to become superficial and thus it happens that more can be gained by taking a short holiday and personally seeing and hearing the author at work. The tired mind is rested, attention is concentrated, and there is freedom from constant interruption. So well is this recognized that there has been of late years an enormous growth of traveling clubs for the most part formed of young surgeons who travel from place to place to see well known teachers at work. Here also as much is gained by those teaching as by the visitors. To a busy surgeon in a teaching hospital a long operating list is not a weary and tiring experience but is an inspiration and a tonic. Keen onlookers are there from every part of the world with whom he can discuss notes and compare methods of treatment. His attention is kept alive and his enthusiasm stimulated by the presence of an appreciative but critical audience. He must feel that he is under close observation and is on his mettle to produce his best. Lasting friendships between surgeons of widely separated countries have often had their foundations in such meetings and for this reason every surgeon is ready to welcome visitors, and he in turn knows that without question he can travel to any country of the world and whatever may be the political feeling between his own nation and that visited, he is sure of a warm welcome from the surgeons he meets. Probably because of the greatly increased ease of travel this spirit is spreading to all medical societies, associations and clubs so that several times a year every large society has a subject introduced or discussed by one or more famous men from some foreign country and even the great barrier of language is broken down. In this latter respect the English-speaking nations are behindhand. They are at present generally speaking poor linguists and whereas surgeons from the Latin, Teutonic, and Scandinavian races can usually speak fluent English, men of the English-speaking races have to make their remarks in their own language. The spirit of comradeship has spread to the big representative bodies and Colleges. At its inception the American College of Surgeons worked in fraternal relationship with the Royal College of Surgeons of England and now this latter body has followed the lead of the American College in insisting that all candidates for its Fellowship must have served an appointment in a recognized hospital. Of late similar cordial and close relationships are being established between the Royal College of Surgeons of England and the Societé National de Chirurgie de Paris.

As a result of these close and friendly relationships there are no longer French, German, Italian, Scandinavian, Russian, English, or American surgeons widely separated by national interests and jealousies, but there is a great brotherhood of medicine consisting of teams working in healthy and friendly rivalry,

not keeping their improvements as jealously guarded secrets but anxious to impart them to other teams. If they are accepted as improvements the reward is sufficient. It has thus come about that in civil medicine the standard of work throughout the civilized world has been raised and the actual standard of any one center of teaching or work is dependent only upon its age and upon the funds at its disposal and not upon its nationality. As a general rule the newest center wherever situated is the best for it has the whole civilized world from which to draw its lesson.

Although so much has been achieved the work is not yet finished. Much may yet be gained by a freer exchange of workers from different medical centers. A first step in this direction has already been instituted and some of the more brilliant young men have been interchanged between American and English centers for a period of some months or a year. Each carries with him the ideals of his Alma Mater and receives in return the methods and knowledge of his hosts. It is by the growth of such methods that the final barrier will be broken down. In its completed form one would hope to see famous teachers and leaders of medicine travel to centers remote from their own for considerable periods and although at present such a step is only an ideal owing to the necessity of these men earning their livings, still it may even now be more extended and in the future should be capable of a much wider application.

Apart altogether from these benefits to medicine this growth of internationalism has an even greater mission. To every thinking man the futility and absurdity of war is so manifest that it is difficult to realize that this is not universally appreciated. The survival of fit individuals or nations is no longer dependent upon war but upon personal endeavor and the finest and most valuable types may be found in any nationality. It has taken 2,300 years for the teachings of Hippocrates to have been widely accepted by medicine, but they have made greater progress in this profession than in any other. By its example it must aim at teaching the civilized world the value of internationalism and strive to remove the bar of language and to establish the true Christian Communism in which all men, whatever their race or creed, have equality of opportunity and each man has a fair reward for his labor. With nations as with men "the greatest of heroes is he who turneth an enemy into a friend."

SIR JAMES WALTON.

THE SURGEON'S INTEREST IN A NEW WORLD

WHEN Pasteur carried to completion his long and brilliant sequence of experiments and deductions, a new realm of nature, that of the universe of microscopic life, stood revealed. What this great discovery has meant to agriculture, industry, sanitation, public health, and medicine can scarcely be exaggerated. What it has meant to surgery in particular is known to all. It forms the very base and foundation of modern surgery. It now appears that we are in the stage of discovery and exploration of another new world, the world of the sub-microscopic entities that may affect the health and activities of all living things, plant and animal. These entities are called the filterable viruses. As yet, this field of research is scarcely three decades old and there is much still unknown. It is not even clear that the term "virus" as now used applies to living things, to non-living chemical compounds, or to both, spanning the unsurveyed border zone between the animate and

the inanimate. Of the existence and some of the effects of these entities called viruses there remains no doubt, however.

It behooves the surgeon to spare some time from his busy daily affairs to think how this new field of investigation may soon affect those affairs. It is already known that certain virus produced diseases have surgical aspects. The disease now known as lymphopathia venerea causes the indolent suppurative bubo that gave it its earlier name of lymphogranuloma inguinale. It probably also causes the great majority of non-traumatic fibrous strictures of the rectum. Since 1910 the relation of filterable virus to tumor formation has been an active subject of investigation and controversy, following the discovery of Rous that a certain form of chicken "sarcoma" was transmissible by the cell free filtrate of the tumor. Rous and his colleagues have recently widened and intensified general interest in this most important question by their work on another tumor, this time in a mammal. They have shown that certain skin papillomas, occurring as an endemic skin disease in wild western cottontail rabbits, may be transmitted by filtrate, and presumably by virus, to the domestic rabbits of the laboratory. But the greatest interest attaches to their further discovery that the papillomas thus transmitted may become definitely and unquestionably carcinomatous. This work is still being actively carried forward, and the time has not yet come when conclusions or generalizations are in order. The possible great significance of it cannot, however, be mistaken. A host of other diseases of man, the animals, and plants are now either proved to be of virus origin, are strongly suspected of having such origin, or come under the classification of possible virus diseases.

The surgeon must try to keep abreast of the general advances made in this new world of nature. He may find that new therapeutic agencies will be required to deal with whole categories of diseases that are now being dealt with by unsatisfactory methods. This may mean the learning of new techniques and the introduction of novel instrumentalities of treatment. It will almost certainly mean a new or modified conception of the common terms "infection," "transmission," "contagion." It may add to the field of practical surgery whole new categories of disease, or remove from it some that are now regarded as exclusively surgical. It may affect deeply our general biological and philosophical thinking. It may alter our conceptions of "living" and "non-living" and of the evolution of life on this planet. HARVEY B. STONE.

MASTER SURGEONS OF AMERICA

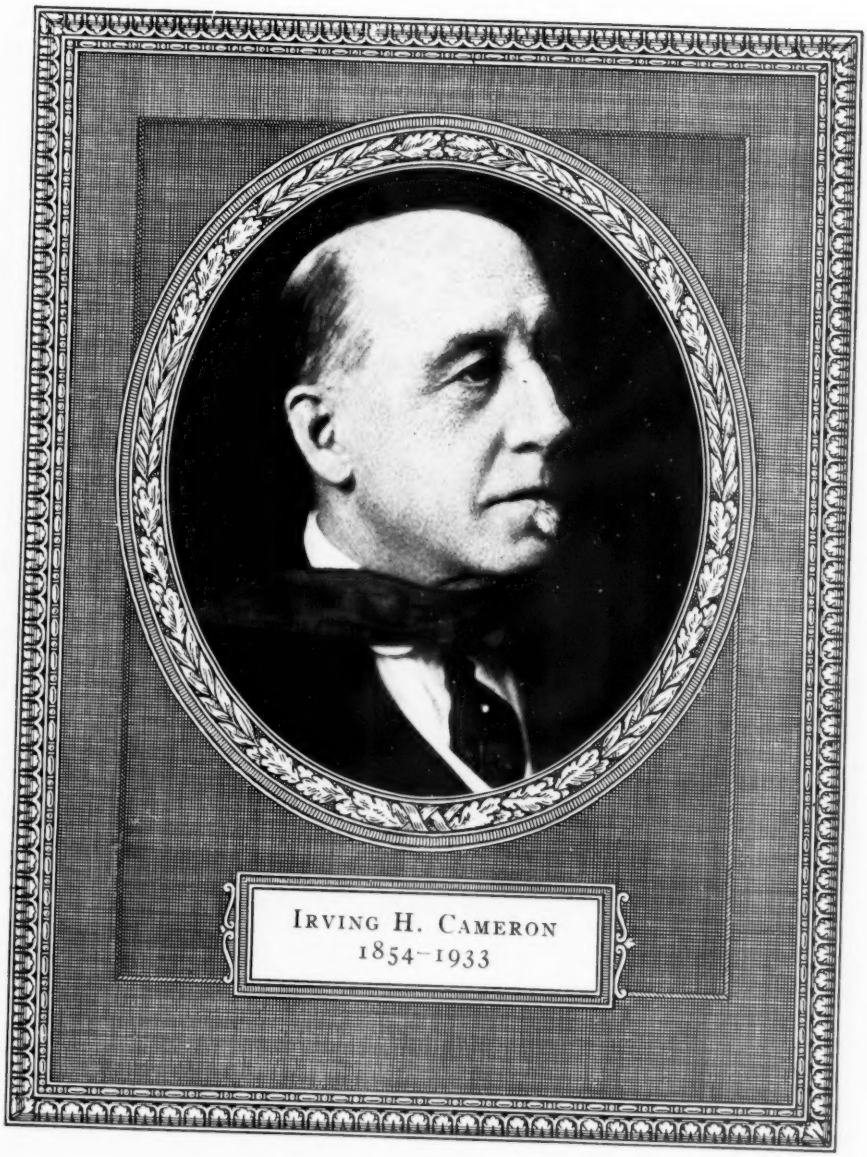
IRVING HEWARD CAMERON

IRVING HEWARD CAMERON, emeritus professor of surgery in the University of Toronto, died at his home on December 15, 1933, after a long illness, in his seventy-ninth year. In his death we have lost one who, with rare qualities of mind and heart, had adorned the profession of medicine for well nigh half a century.

Mr. Cameron[1] was born in Toronto, the son of Sir Matthew Crooks Cameron, Chief Justice of the Common Pleas of the Province of Ontario. He was educated at Upper Canada College and the University of Toronto. Beginning undergraduate study as a student of law, he transferred to the course in medicine, obtaining his Bachelor's degree in 1874. Early in his career he participated actively in university affairs. As a member of the Senate he played an important and effective part in bringing about the reorganization of the Faculty of Medicine in the University of Toronto in 1887. In that year he became professor of the principles of surgery and of surgical pathology on the new staff. In August, 1892, he was appointed professor of clinical surgery, and in 1897 he succeeded the late Dr. W. T. Aikin in the chair of surgery and clinical surgery. He retired in 1920 with the rank of emeritus professor. Mr. Cameron was a loyal son of his Alma Mater and served her interests with unswerving devotion, often at great personal sacrifice. A consultation had to be arranged or cancelled if it interfered with a meeting of a committee of the Senate of which he happened to be a member. The same spirit influenced and controlled his activities in the hospital and the clinic. He played a leading part in the development of many projects relating to the university. He was one of the founders of the Alumni Association and at one time its president. He was among those who established the *University of Toronto Monthly*, and for a number of years was chairman of the editorial board. He was prominent in initiating the movement that led to the erection of Convocation Hall and in the organization of the Faculty Union.

In connection with the Toronto General Hospital and the Hospital for Sick Children he rendered untiring service as surgeon. His influence was great in securing adequate provision for the teaching of medical students in these hospitals. For a time, early in his career, he was on the staff of St. Michael's Hospital, and for many years was a leading surgeon in the St. John's Hospital for Women, operated by the Sisters of St. John the Divine, on Major Street. In a

[1]He preferred to be called "Mister" rather than "Doctor" following the British precedent for surgeons in that regard.



IRVING H. CAMERON
1854–1933

broader field Mr. Cameron exercised an important influence. He was one of the founders of the *Canadian Journal of Medical Sciences;* past president of the Canadian Medical Association (president in 1908), and of the Toronto branch of the British Medical Association; a member of many societies, including the Société Internationale de Chirurgie and the British Association for the Advancement of Science. He was the author of numerous papers, addresses, and reviews.

During the Great War Mr. Cameron rendered conspicuous service in organizing the surgical department of the Ontario Hospital for wounded soldiers at Orpington in Kent, where he was chief surgeon. He filled a similar position in the Canadian Hospital at Taplow. After returning to Canada at the close of the War he was appointed to the Board of Consultants for Canada. In that capacity he traveled long distances throughout the country, visiting hospitals and rendering service of the highest order.

In acknowledgment of his attainments and his service to humanity he was the recipient of many honors. These included Doctor of Laws of the University of Edinburgh (Hon.), honorary fellowships in the Royal College of Surgeons of England, the Royal College of Surgeons of Edinburgh, the Royal College of Surgeons of Ireland, and the Royal College of Surgeons of Canada. He was also a charter fellow and honorary fellow of the American College of Surgeons.

Mr. Cameron possessed qualities all too rare in the medical profession. Beyond the limitations of books devoted to medical science, he was a student of general literature and a classical scholar of no mean order. Endowed with an exceptional memory, he was proficient in apt quotation, a power he used with great effect both in public and in private. With these attainments it was natural to find him fastidious in his use of English and intolerant of slovenly methods of expression. A false quantity in pronunciation would often arrest his attention and induce comment. He objected to the term "appendicitis" because it was a hybrid of Latin and Greek and endeavored, I fear unsuccessfully, to induce his students to call it "epityphlitis." There was a charm, almost unique, in his departure from narrow technicalities of medical study and in his effort to interest the student in the broader studies of a cultivated man of letters.

Withal Mr. Cameron was a skilful surgeon enjoying the confidence and deep affection of a large clientele in the community. He was also an inspiring teacher. As a young man he became a disciple of Lister and was among the first to introduce into surgical practice in this country the principles enunciated by that great master. Among the heroes he worshipped, both in science and in literature, Lister stood *facile princeps.* If during one of his annual visits to Great Britain he went to Glasgow he would visit the Royal Infirmary and the old ward where Lister began the investigations that led to his great discovery. That indeed was hallowed ground to Mr. Cameron. These visits were akin to paying homage at the shrine of one of the immortals. Little wonder that he was among those who

protested vehemently when, a few years ago, the trustees of the Royal Infirmary determined to demolish the old building. When in spite of protest this "vandalism" was accomplished, Mr. Cameron succeeded in securing a brick from the wall of Lister's ward. This brick was presented to the Faculty of Medicine in Toronto and now lies embedded in the wall of the library of the Banting Institute, immediately below the portrait of Lister. A suitable inscription narrates its story.

Mr. Cameron's unfailing courtesy, his liberal hospitality, and his personal culture and charm secured for him the esteem and devotion of many. His old students and a host of friends and admirers both in this country and overseas mourn his loss.

A. PRIMROSE.

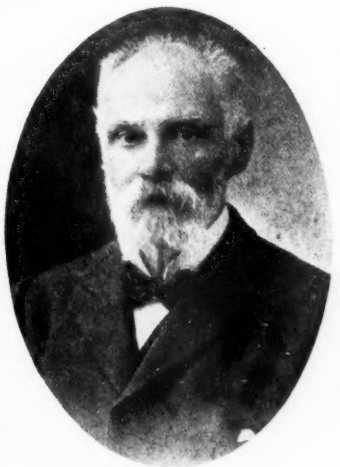
LANDMARKS IN SURGERY

EDOARDO BASSINI

His Rôle in the Development of Hernial Surgery

LEO M. ZIMMERMAN, M.D., F.A.C.S., and RICHARD E. HELLER, M.D., Chicago, Illinois

EDOARDO BASSINI is recognized as the father of modern hernial surgery because, alone, he revolutionized the treatment of inguinal hernia. He found hernial surgery in practically the same state of development it had reached during the Roman era; he left it where it stands today. Not often has it been given to one man so completely to effect a turning point in the development of an important phase of surgical therapeutics. It is a fact that he had a truer grasp of the problems involved in the surgical treatment of inguinal hernia than have had most of those who have since "modified" and "improved" the Bassini operation. His treatise on the treatment of inguinal hernia is a masterpiece of surgical literature; scientific, well written, and as true today as it was when he wrote it, 50 years ago.



Prof. Edoardo Bassini, 1844–1924

Edoardo Bassini was born in Pavia, in Lombardy, on April 14, 1844. He received his doctorate in medicine from the University of Pavia in 1866, at the early age of 22 years. This was the year of the liberation and unification of Italy, and young Bassini eagerly participated in the movement for national freedom. Although a graduate in medicine, he chose to fight as a private in the ranks, and engaged in two campaigns in that capacity. In the second of these he sustained a bayonet wound of the groin which festered and resulted in a fecal fistula. He was taken prisoner, and remained in the hospital for a number of months. When eventually discharged, he returned to Pavia, where he was treated by Luigi Porta, chief of the University Surgical Clinic, who subsequently became his teacher in surgery.

After his recovery, Bassini served as second assistant to Porta. He was particularly interested in anatomy and surgical pathology, and even at this early period made numerous dissections of the inguinal region. To complete his studies, he visited other famous clinics: Billroth's in Vienna, Langenbeck's in Berlin, and Lister's and Spencer-Wells' in London. In 1874, at the age of 30, he was invited to return to Pavia as first assistant to Porta, and to teach in the university. The following year his chief became ill, and Bassini carried on his work. When Porta died, however, the chair was awarded to someone else, and disappointed, Bassini resigned from the university and returned to London.

Six months later he was called to Parma to teach clinical surgery, and 2 years later he became head of the department of surgery at Spezia. In both institutions he introduced Listerian methods, one of the first to bring antiseptic surgery to Italy. In 1882 he was appointed to the chair of surgical pathology of the University of Padua, in which famous institution he spent the following 37 years of his life. He became professor of clinical surgery in 1888, and he held this position until his retirement at the age of 75, in 1919. During this long and fruitful period, his epoch-making work on hernia appeared, as well as numerous other contributions to surgical literature, which won for him many honors. He was simple, almost austere in his tastes, of rigid moral fiber, a meticulous and cautious operator, and a kindly and interesting teacher. It is not surprising that he enjoyed the affection, as well as the admiration of his associates and pupils. He died in Verona, at the age of 80, on July 19, 1924.

To appreciate Bassini's contribution to the treatment of inguinal hernia, it is necessary to review briefly the status of hernial surgery at the time his work appeared. The earliest mention of hernia in

From the Department of Surgery, Northwestern University Medical School.

medical literature is found in the books of Celsus of the first century, A.D. Here is described an operation consisting of dissection and excision of the sac, with or without suture of the wound. This procedure, surprisingly advanced in its conception, was entirely lost during the Dark Ages, and was not rediscovered until the 19th century. Paul of Ægina, in the 7th century A.D. described a method consisting of double ligation an l excision, *en masse*, of sac, cord, and testicle. This mutilating and ineffective operation persisted throughout the Middle Ages, and represented, perhaps, the least objectionable of a number of irrational and barbaric methods by which the depth of the decay of medieval surgery may be measured.

One of the widely used among these methods was the cautery. Both the actual iron and escharotics were used, and the skin, subcutaneous tissues, and fascias were burned down to and including the pubic bone. The wound was then allowed to heal by granulation, in the hope that the scar would be sufficiently resistant to prevent further herniation. Other favored methods were the "royal operation" and the *punctum aurum*. The former, so called because it spared the testicle and preserved the generative powers to provide new subjects for the king, consisted merely of an incision over the hernia, in the direction of the spermatic cord, and suture of the sac *in situ*. The latter was devised by Geraldus of Metz and practiced by Ambroise Paré. It consisted of twisting a gold wire about the cord and sac, in the attempt to prevent further descent of bowel into the hernia. Obviously, if the wire were tight enough to effect this purpose, the circulation to the testis was compromised; and if not, nothing was accomplished. Other measures consisted of various types of percutaneous ligation of sac and cord, with, perhaps, compression of the tissues by diverse devices, and of inversion of skin or other substances into the canal, in the hope of blocking the rupture. All of these operations were dangerous, in view of the ignorance of the operators and their lack of cleanliness. They were painful and mutilating, and offered no real promise of success. It is no wonder, then, that reputable surgeons, as late as the beginning of our own era advised against surgery for the treatment of reducible inguinal hernia.

During this period, however, the basis for an intelligent approach to the hernia problem was being laid. The anatomy of the inguinal region was thoroughly studied by men whose names are still attached to structures in that area: Vesalius, Scarpa, Cooper, Gimbernat, Hesselbach. The nature of hernia was established, and its various types described. The 19th century brought anesthesia, hemostasis, and antisepsis, the 3 major discoveries that have made modern surgery possible. With the inception of the modern era in surgery, attention was again directed toward the radical cure of reducible hernia.

The pioneers of post-Listerian herniology, Czerny, Lucas-Championière, Macewen, and Marcy, rediscovered, with various minor and insignificant additions, the operation described by Celsus, almost two thousand years before. Thus, in twenty centuries, no advance in technique had been made, until Bassini blazed new paths for the development of the surgical treatment for inguinal hernia.

The literature of the period in which Bassini's studies were in progress gives an illuminating picture of the results of hernial surgery of the time. The operations most widely in use were those of Wood and Czerny, which, like that of Celsus, consisted essentially of ligation and excision of the sac, with or without suture of the pillars of the external ring. Halsted, in 1890, wrote: "Just now, most of the so called radical cure operations are under a cloud. They have not withstood the test of time. Modern textbooks of surgery refer to operations for the radical cure of hernia with more or less misgiving." He quoted Bull, who reported recurrence rates of 40 per cent in the first year, and practically 100 per cent failures within 4 years. Bull advised dropping the term "cure," and considered operation indicated merely for the temporary relief it afforded.

In the same issue of the Langenbeck's *Archiv* in which Bassini's first full report was made, there is a review of hernial surgery from Billroth's clinic, with comparative citations from the literature. The death rate was about 6 per cent, and the incidence of recurrences was frightful. Over one-third of the operations were failures, and were marked by prompt reappearance of the hernia. The late results were admittedly much poorer.

Bassini's interest in the problem of inguinal hernia dated back to his experiences in the Institute of Pathology in Pavia, in 1873. As a clinician, he was impressed by the fact that all of the contemporary radical operations necessitated the subsequent wearing of a truss if recurrence were to be prevented. This was true of the first few patients he operated upon by the prevailing methods. He felt that the essential inadequacy of all the available operations was that the repair depended upon the occlusion of the hernial opening by a single layer of scar tissue, which was further weakened by the passage through it of the spermatic cord. The solution to the problem, he thought, might lie in a physiological reconstruction of the inguinal canal for the passage of the cord, so that it again possessed an internal and an external opening and an anterior and a posterior wall. Applying his knowledge of anatomy, and experimenting on the cadaver, he evolved his renowned method which, he believed, fulfilled the requirements of a radical operation; that is, it would cure the hernia without necessitating the subsequent wearing of a truss. The first report of his operation was made before the Italian Surgical Society in 1887, and covered a series of 42 cases. The following year, before the same body, he reported a series of 102 cases successfully treated by his technique. His comprehensive treatise on "The Treatment of Inguinal Hernia," which appeared in the *Archiv fuer klinische Chirurgie* of 1890 made his discoveries available to the rest of the surgical world.

The technique described in this report differs somewhat from that usually taught as the Bassini operation. The high ligation and excision of the sac are clearly and concisely described. He then separated the internal oblique, transversus abdominis and fascia verticalis Cooperi (transversalis fascia) from the aponeurosis of the external oblique above, and from the subjacent retroperitoneal tissue. The "triple layer" was then carefully sutured with interrupted silk stitches to the shelving portion of Poupart's ligament. The two lowermost sutures included the outer margins of the rectus abdominis muscle. Thus, the internal ring and the posterior wall of the canal were restored. The aponeurosis was then reunited over the cord, and the anterior wall of the canal and the external ring reconstructed.

Bassini recognized the fact that large indirect hernias dilated the internal ring downward, depriving the canal of its obliquity. He emphasized the necessity of closing the floor from below upward, so that the newly formed internal ring lay above and lateral to the external ring, restoring obliquity to the canal. He appreciated the valve-like closure of the canal by the approximation of the anterior and posterior walls, when abdominal pressure was applied. He differentiated between direct and indirect hernias, and described their variations in location, structure, and treatment.

The report is based on a consecutive series of 262 cases, with a brief description of each. There were no operative deaths among the 216 patients, upon whom 251 operations for non-strangulated hernia were done. To determine the end-results of the operation, the patients were followed for a number of years. Of the 251 cases, he followed all but 4 for periods ranging from 1 month to 4½ years, itself a commendable achievement in clinical research. Of the total, 108 cases were followed for over 1 year. There were only 7 recurrences in the total series of 251 operations (2.7 per cent), a record of which any surgeon of today could well be proud. The subject of inguinal hernia is so completely and masterfully handled in this treatise that little of significance has since been added. In the light of our present day knowledge of hernia, the fullness of the author's understanding of the problems involved is astounding. Many of our contemporary herniographers could study with profit, this contribution of 50 years ago.

The response to Bassini's work was instantaneous. His methods were widely adopted. Overnight, hernial surgery of classical antiquity gave way to that of today. Surgeons the world over came again to visit the clinic at Padua. In the tradition of Vesalius, Harvey, Morgagni and Scarpa, Bassini added his name to the list of those who have made Padua a center for the dissemination of knowledge to the medical world.

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THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE charge is often made that physicians are so much engrossed in their special field that they give no thought to the larger problems of social and political life. It is true that we have produced few politicians but not true that the physicians neglect the broader cultural fields or social philosophy. Two books have recently appeared that emphasize this catholicity of thought of our profession, Royster's *Medical Morals and Manners* and Elliott's *Scalpel and Sword*.

Royster[1] has gathered together in one volume more than thirty addresses upon general subjects he has given before professional and lay organizations. These papers with their wit, homely wisdom, and keen insight into the working of the common mind of mankind make a most interesting and instructive collection. Some will like "Surgical Sense" or "The Humanity of Surgery," others "Women and the Doctor" or "Athletics and Scholarship," and others like myself the thumbnail biographies of Sims, Budd, and Strudwick, but wherever one delves he will turn over nuggets of wisdom and much constructive thought, and be fortified in his ideals by the kindly humanity that pervades the whole.

Sir James Elliott[2] (Wellington, New Zealand) brings us something different and most intriguing—chapters from a life that has been filled with most interesting experiences. The North American surgeons will be attracted most by the chapters describing Wellington with the vivid characterizations of its citizens and those that picture the life in New Zealand because so few of us have visited Otago University, known the delightful Macris or are acquainted with the charming mountains and valleys of Elliott's adopted home. After reading the book one does not need to be told that the author came from Ulster since from every page bubbles up an inimitable Irish humor. Elliott's life in Edinburgh as a student, his experiences in the Boer War, the story of the New Zealanders in the World War, and the reminiscences of his travels round out a most readable and interesting book.

ALLEN B. KANAVEL.

THE literature of the endocrine glands from the earliest times is reviewed by Sir Humphry Rolleston in his recent classic presentation of the knowledge of the world on this subject.[3] But, extraordinary as the review of the fundamental studies to be found in the library is, the value of the book to present day workers derives from its analysis of recent investigations. It is, thus, not only complete but current. Brief biographies scattered through the text, as the discussion of a man's work comes up, make an inspiring addition. Into the 500 pages which compose this volume are packed, literally crowded, thousands of references which are given intelligent evaluation. For example, the chapter on the pituitary has 14 references on the history, 16 on the embryology, 43 on the anatomy (the last 10 from 1935), 55 on the histology, about 225 on the physiology, 37 on introduction to clinical conditions of the pituitary, about 100 on the history of acromegaly, and about 50 on the pathogenesis; the review of the diseases of the pituitary covers at least 800 additional references, the total for this chapter reaching 1200 titles or more. The study of literature in regard to the thyroid is even more extended. The parathyroids, adrenals, gonads, pancreas and islands of Langerhans, thymus, pineal body, carotid body, coccygeal body, liver, stomach, spleen, and diseases of doubtful endocrine origin, are taken up.

Controversial subjects enable the author to bring together the opinions of various men in a manner that is enlightening to the student. The quality of the book in this regard is well illustrated by the following paragraph on the disputed etiology of toxic goiter, in which the nervous hypothesis is reviewed: "Trousseau in 1860 regarded the disease as a neurosis analogous to hysteria. On November 27, 1860, Handfield Jones (1819–1890) read a paper on 'Proptosis, Goitre and Palpitation' before the Royal Medical and Chirurgical Society and concluded that the exophthalmos was caused by effusion of fluid behind the eyeball and that the disease was essentially a debility of the vasomotor nervous system. The paper, not thought worthy of the Society's 'Transactions,' was printed in its 'Proceedings,' and together with the discussion was reported in the *Lancet*. Subsequently changes were described in the sympathetic by Peter, von Recklinghausen, and Virchow. It was also suggested by Koeben (1865) and Piorry that pressure of the thyroid on the sympathetic in the neck was responsible for the symptoms, and in 1897 Pierre Marie adopted this explanation for cases (goitre Basedowifie) of dyspnea and other symptoms, which he distinguished from Graves's disease. In a case recorded by S. Wilks in 1870 Moxon (1836–1886) examined the sympathetic, but could not confidently say that it was abnormal; Goodhart in 1874 de-

[1] MEDICAL MORALS AND MANNERS. By Hubert Ashley Royster, M. D. Chapel Hill, N.C.: The University of North Carolina Press, 1937.
[2] SCALPEL AND SWORD. By Sir James Elliott. Wellington, New Zealand: A. H. and A. W. Reed, 1936.
[3] THE ENDOCRINE ORGANS IN HEALTH AND DISEASE. By Sir Humphry Davy Rolleston. London: Oxford University Press, 1936.

scribed the sympathetic trunk as looking red, but the ganglion cells as microscopically normal; Ranvier also found the sympathetic system normal. In 1863 T. Laycock (1812–1876) stated that the responsible lesion was in the cilio-spinal region of the spinal cord, and in 1874 Lauder Brunton (1844–1916) suggested that the third cervical ganglion of the sympathetic was the site of disease. The importance of the nervous system in causing symptoms was fully recognized in the second half of the nineteenth century, and Graves's disease was generally explained on these lines; in his article in Dechambre's *Encyclopedie des sciences medicales* (1883) Rendu (1844–1902) gave as a synonym 'nevrose thyro-exophthalmique.' But in Hilton Fagge's 'Principles and Practice of Medicine' (1886) it was considered among the diseases of the blood vessels. The general impression that exophthalmic goitre was of nervous origin was shown by a discussion in Paris on its relations with tabes in 1888–89 in which Barie, who introduced it, insisted that the signs of exophthalmic goitre might occur in the course of tabes. Ballet and Joffrey also spoke on the subject.

"Recently the nervous factor has been partially revived by Labbe and his collaborators (1931, 1933) in the view that toxic goitre is due to a combination of (a) hyperthyroidism and (b) a neuro-vegetative syndrome or para-Basedowism. According to Drouet, Jeandelize, and Gault (1934) para-Basedowism, which causes exophthalmos, tachycardia, tremor and goitre, is due to excessive secretion of the thyrotropic hormone of the anterior pituitary."

Following this the thyroid, thymus, adrenal, and pituitary hypotheses are similarly presented.

We should be extremely grateful to Sir Humphry Rolleston for this monumental summary of the work done in the endocrine field. PAUL STARR.

AN EXCELLENT example of a type of publication more common in the French than in the American literature is *Chirurgie du Cancer du Poumon*.[1] Modeled perhaps on the inaugural thesis, based often on a very meager clinical material, it presents a complete review of the literature on the subject considered. It is more a work of scholarship than of clinical investigation. It is valuable, as this volume is valuable, because it collects and condenses and so makes easily available what is elsewhere widely scattered. Here the experimental, clinical, and technical aspects of the surgery of cancer of the lung are thoroughly reviewed. The complete bibliography makes the volume doubly valuable. JEROME R. HEAD.

IN THE second edition[2] of his 661 page book on *Proctology*, Frank Yeomans has completely and expertly covered the field of rectal disease.

A chapter by chapter comparison with the 1929 edition shows little change as far as basic principles are concerned. Nevertheless, there are many valuable additions which indicate that the author has brought his book up to 1936. Among the notable changes are: new information on the injection treatment of hemorrhoids—technique of phenol in oil solution; oil-soluble anesthetics in pruritus ani, fissures and other rectal conditions; radiodermatitis; histopathology of anal crypts; recent views on the etiology and therapy of chronic ulcerative colitis; pharmacological classification of drugs used in amebiasis, and therapeutic results of same; agranulocytic angina—anorectal involvement; lymphopathia venerea in the etiology of rectal stricture; results of sympathetic ganglionectomy and ramisectomy in megacolon; melanosis coli; pectenosis and pectenotomy; revision of the section on angiomas of colon and rectum; subarachnoid injection of alcohol for relief of intractable pain in advanced malignant disease; two-stage operation for carcinoma of the rectum—the technique of Rankin and of Lahey; revised statistics of the results of treatment of rectal carcinoma by irradiation and by excision.

Photography and drawings with a number of colored plates are liberally used to illustrate the subject matter. Photographs of a number of obsolete anoscopes (Beach & Sims) and dilators could have been eliminated. Too much emphasis, both written and pictorial, is placed on the clamp and cautery type of hemorrhoidectomy, which is rapidly losing popularity. The Whitehead operation is mentioned and discussed, only to be condemned by the author, a fact based on well founded objections. Great emphasis, in fact 100 pages are utilized in detailing diagnostic methods and the importance of thorough proctologic examinations.

The section on malignant tumors, covering at least one-fourth of the book, presents the reader with a broad and unbiased view of every phase of this very important subject. The volume is an ably constructed, well balanced work which has been and will continue to be useful to proctologists, surgeons, and general practitioners alike.

THOMAS JAMES MERAR.

DURING most of the twentieth century Dr. Jackson[3] and his associates have been devoting the major portion of their time to educating the profession in the recognition and treatment of foreign bodies in the air and food passages. The latest contribution of the Jacksons is a mass of clinical facts and data collected from these 30 years of experience. In the 600 pages are 10 chapters dealing with the etiology, symptomatology, pathology, and treatment of foreign bodies in the air and food passages. In tabulated form are over 3100 consecutive cases taken from the files of the Jackson Clinic.

[1] LA CHIRURGIE DU CANCER DU POUMON; BASES ANATOMOCLINIQUES ET EXPÉRIMENTALES; TECHNIQUE OPÉRATOIRE. By O. Lambret, H. Malatray, and J. Driessens. Paris: Masson et Cie., 1936.

[2] PROCTOLOGY; A TREATISE ON THE MALFORMATIONS, INJURIES AND DISEASES OF THE RECTUM, ANUS AND PELVIC COLON. By Frank C. Yeomans, A.B., M.D., F.A.C.S., M.R.S.M.(Lond., Hon.). 2d ed. New York and London: D. Appleton-Century Co., 1936.

[3] DISEASES OF THE AIR AND FOOD PASSAGES OF FOREIGN-BODY ORIGIN By Chevalier Jackson, M.D., Sc.D., F.A.C.S., LL.D., and Chevalier L. Jackson, A.B., M.D., M.Sc.(Med.), F.A.C.S. Philadelphia and London: W. B. Saunders Co., 1936.

These readily lend themselves to study so that the endoscopist may find in them a parallel case and the solution to many of the baffling problems which he encounters.

A few statistics are of special interest. From an etiologic standpoint over 81 per cent occur in patients under 15 years of age and over 90 per cent are charity or semi-charity, indicating that foreign bodies occur more frequently, in the poor. In a series of 1400 cases, over 200 were overlooked due to failure to consider the possibility of a foreign body in patients with pulmonary symptoms and over 87 per cent of these gained access through carelessness.

The book is complete with illustrations of typical cases as well as descriptions of and solution of the problem involved in the removal of foreign bodies in different cases.

Undoubtedly this latest work will prove as popular as Dr. Jackson's previous writings. It is both enriching and important in its information and will not disappoint those who consult it for a complete solution of the problem which is involved.

JOHN F. DELPH.

THE excellent example set by other recent authors of textbooks on the subject of obstetrics has been followed by Schumann by making his recent book[1] of reasonable size. The volume is not too large, either in dimensions or in the number of pages it contains. This means that the subject matter has been condensed to a minimum.

The author has emphasized the fundamentals of obstetrics and has given only brief mention to subjects that are of rare occurrence, and the book is notable for its lack of historical data. The author regrets that the latter (historical data) cannot be included in the text, but the reviewer feels that this omission is to be highly commended. Students may be referred to the proper source for such information.

The contents of the book are arranged in logical order and this text should be a valuable aid to the student of Schumann, since it clearly and briefly deals with the subject of obstetrics from the viewpoint of the author. The book is adequately illustrated and contains a comprehensive bibliography.

CHESTER C. DOHERTY.

[1] A TEXTBOOK OF OBSTETRICS. By Edward A. Schumann, A.B., M.D., F.A.C.S. Philadelphia and London: W. B. Saunders Co., 1936.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

CANCER AND DIET; WITH FACTS AND OBSERVATIONS ON RELATED SUBJECTS. By Frederick L. Hoffman, LL.D. Baltimore: The Williams & Wilkins Co., 1937.

RECENT ADVANCES IN ORTHOPÆDIC SURGERY. By B. H. Burns, B.A., B.Ch., F.R.C.S., and V. H. Ellis, M.A., B.Ch., F.R.C.S. Philadelphia: P. Blakiston's Son & Co. Inc., 1937.

SAFE CHILDBIRTH; THE THREE ESSENTIALS: (1) ROUND BRIM, (2) FLEXIBLE JOINTS, (3) NATURAL POSTURE. By Kathleen Olga Vaughan, M.B.(Lond.). With foreword by Howard A. Kelly, M.D., LL.D. Baltimore: William Wood & Co., 1937.

VEIT'S HANDBUCH DER GYNAEKOLOGIE. 3d rev. enl. ed. Edited by Dr. W. Stoeckel. Vol. 12, 1st half—GESCHICHTE DER FRAUENHEILKUNDE I; DIE FRAUENHEILKUNDE DER ALTEN WELT. By Dr. Paul Diepgen. Munich: J. F. Bergmann, 1937.

HERTZLER'S MONOGRAPHS ON SURGICAL PATHOLOGY. SURGICAL PATHOLOGY OF THE THYROID GLAND. By Arthur E. Hertzler, M.D. Philadelphia, Montreal and London: J. B. Lippincott Co., 1936.

SENILE CATARACT; METHODS OF OPERATING. By W. A. Fisher, M.D., F.A.C.S. 3d rev. ed. Chicago: H. G. Adair Printing Co., 1937.

OPHTHALMOSCOPY, RETINOSCOPY AND REFRACTION; WITH NEW CHAPTER ON ORTHOPTICS. By W. A. Fisher, M.D., F.A.C.S. 4th rev. ed. Chicago: H. G. Adair Printing Co., 1937.

LOMBOARTRITE E SCIATICA VERTEBRALE; SAGGIO CLINICO. By V. Putti. Bologna: L. Cappelli, 1936.

CHRISTIAN R. HOLMES; MAN AND PHYSICIAN. By Martin Fischer. Springfield, Illinois, and Baltimore, Maryland: Charles C. Thomas, 1937.

THE OCULAR FUNDUS IN DIAGNOSIS AND TREATMENT. By Donald T. Atkinson, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1937.

HANDBOOK OF ORTHOPAEDIC SURGERY. By Alfred Rives Shands, Jr., B.A., M.D., and Richard Beverly Raney, B.A., M.D. St. Louis: The C. V. Mosby Co., 1937.

TRAUMA AND DISEASE. Edited by Leopold Brahdy, B.S., M.D., and Samuel Kahn, B.S., M.D. Philadelphia: Lea & Febiger, 1937.

THE THYROID; AND ITS DISEASES. By J. H. Means, M.D. Philadelphia, Montreal and London: J. B. Lippincott Co., 1937.

SOURCE BOOK OF ORTHOPAEDICS. By Edgar M. Bick, M.A., M.D. Baltimore: The Williams & Wilkins Co., 1937.

SYNOPSIS OF PEDIATRICS. By John Zahorsky, A.B., M.D., F.A.C.P. Assisted by T. S. Zahorsky, B.S., M.D. 2d ed. St. Louis: The C. V. Mosby Co., 1937.

MEDICAL UROLOGY. By Irvin S. Koll, B.S., M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1937.

A MANUAL OF RADIOLOGICAL DIAGNOSIS; FOR STUDENTS AND GENERAL PRACTITIONERS. By Ivan C. C. Tchaperoff, M.A., M.D., D.M.R.E.(Camb.). Baltimore: William Wood & Co., 1937.